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Schad

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(54) **VALVE ASSEMBLY FOR AN INJECTION MOLDING MACHINE**

(56) **References Cited**

(71) Applicant: **Athena Automation Ltd.**, Vaughan (CA)

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(72) Inventor: **Robert D. Schad**, Toronto (CA)

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(73) Assignee: **Athena Automation Ltd.**, Vaughan (CA)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(21) Appl. No.: **14/199,487**

Primary Examiner — Tim Heitbrink

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Related U.S. Application Data

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(51) **Int. Cl.**

B29C 45/43	(2006.01)
B29C 45/34	(2006.01)
B29C 45/42	(2006.01)
B29C 45/72	(2006.01)
B29C 45/82	(2006.01)

(57) **ABSTRACT**

A valve assembly for use with a part handling assembly of an injection molding machine includes a housing having a first tooling port for fluid communication with a first set of receivers on the part handling apparatus and a second tooling port for fluid communication with a second set of receivers on the part handling apparatus. First and second vacuum channels extend through the housing and are provided with respective first and second vacuum closure members to provide selective fluid communication between a vacuum source and the first and second tooling ports, respectively. First and second pressure channels extend through the housing and are provided with respective first and second pressure closure members to provide selective fluid communication between a pressurized fluid source and the first and second tooling ports, respectively. The first pressure closure member is moveable independently from the first vacuum closure member, and the second pressure closure member is moveable independently from the second vacuum closure member.

(52) **U.S. Cl.**

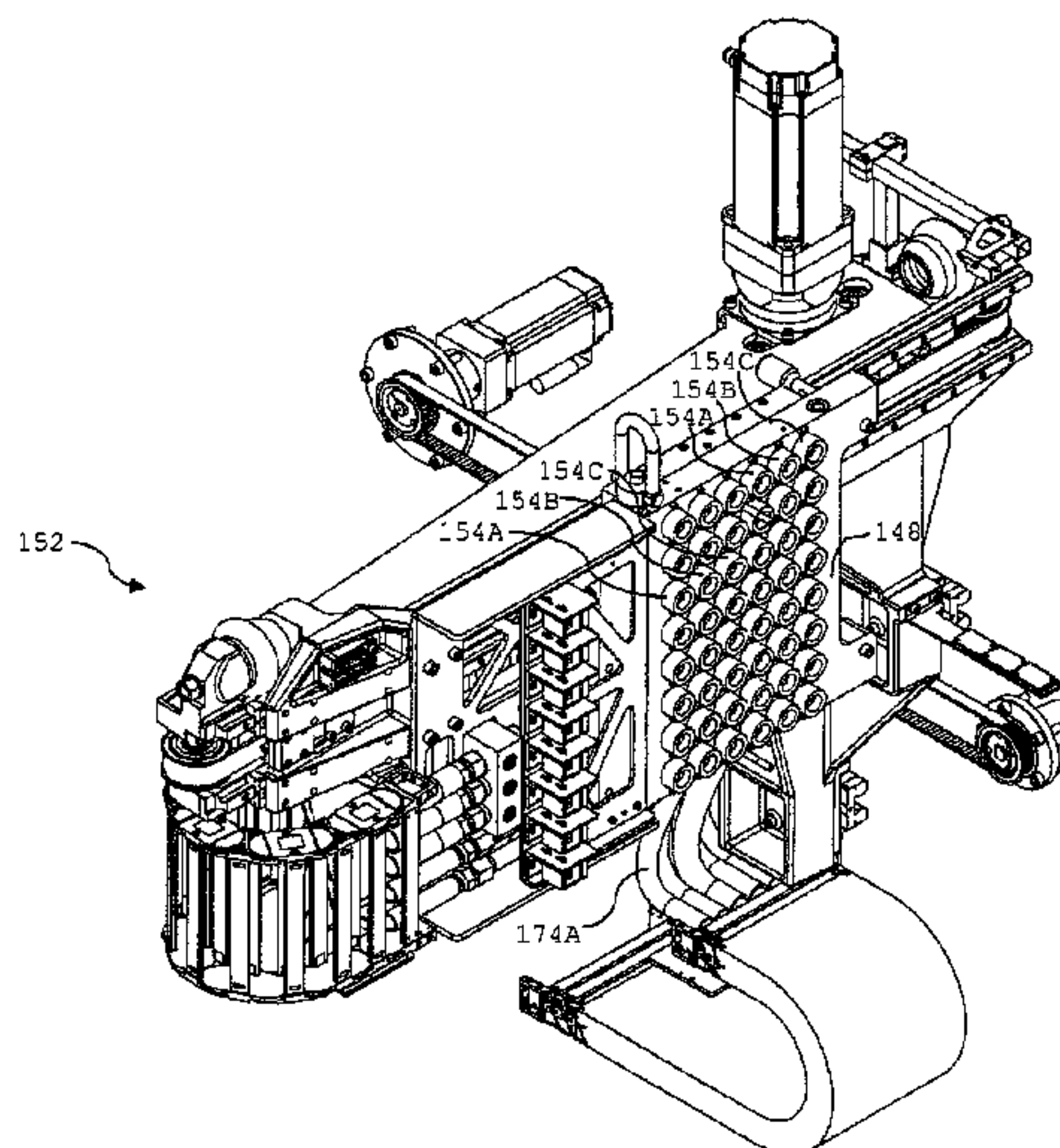
CPC **B29C 45/34** (2013.01); **B29C 45/4225** (2013.01); **B29C 2045/7214** (2013.01); **B29C 2045/822** (2013.01)

USPC **425/139**; 425/552; 425/556; 425/576

(58) **Field of Classification Search**

USPC 425/139, 552, 556, 572
See application file for complete search history.

22 Claims, 14 Drawing Sheets



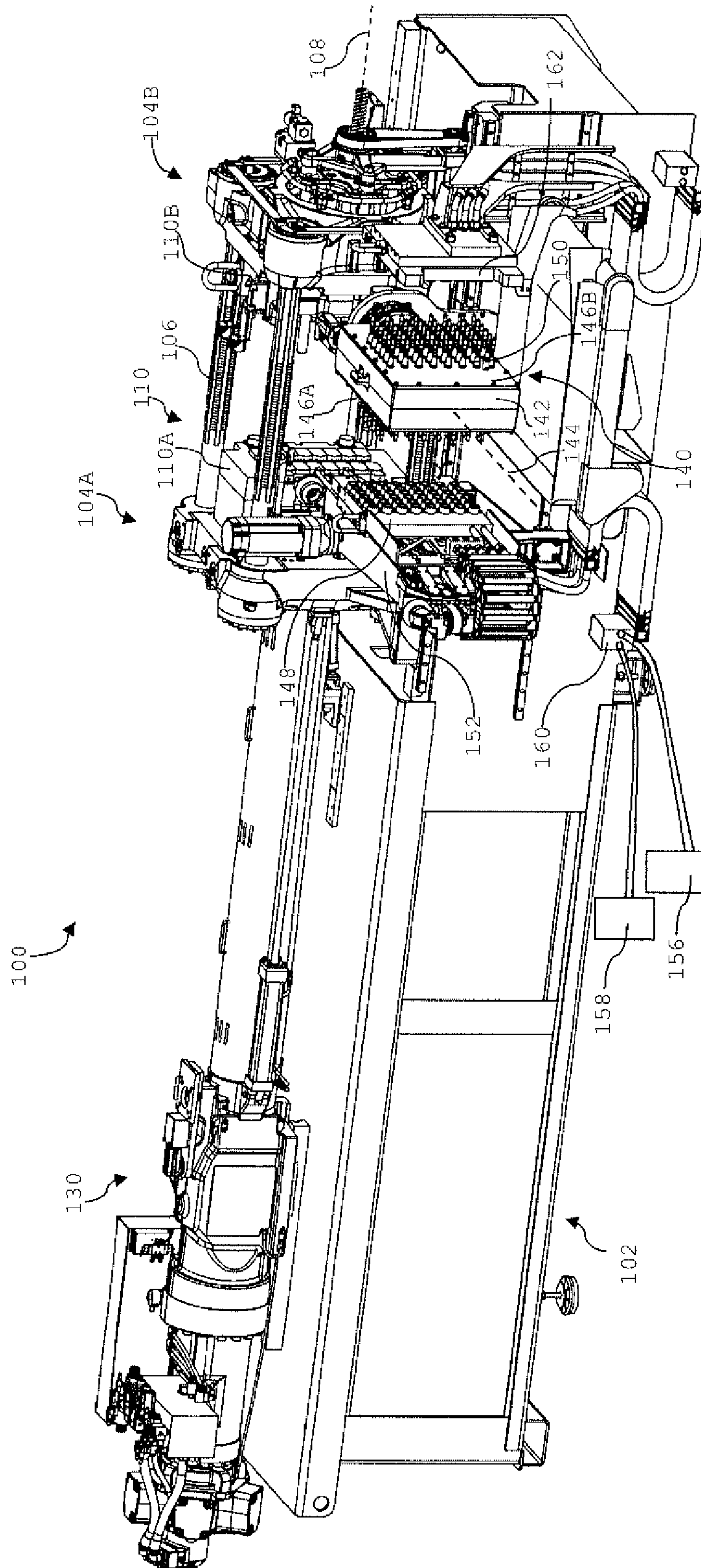


FIG. 1

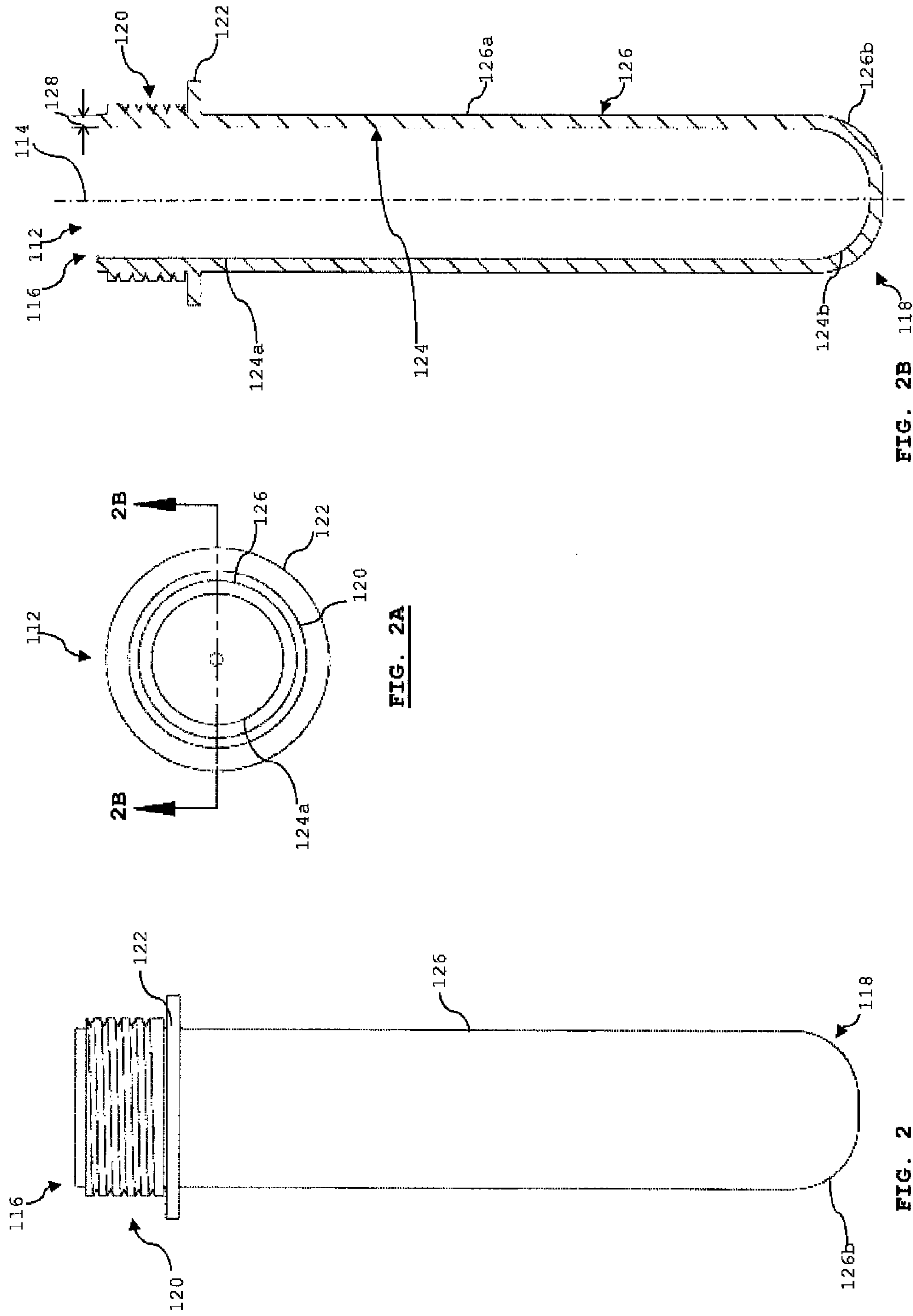


FIG. 2A

FIG. 2B

FIG. 2

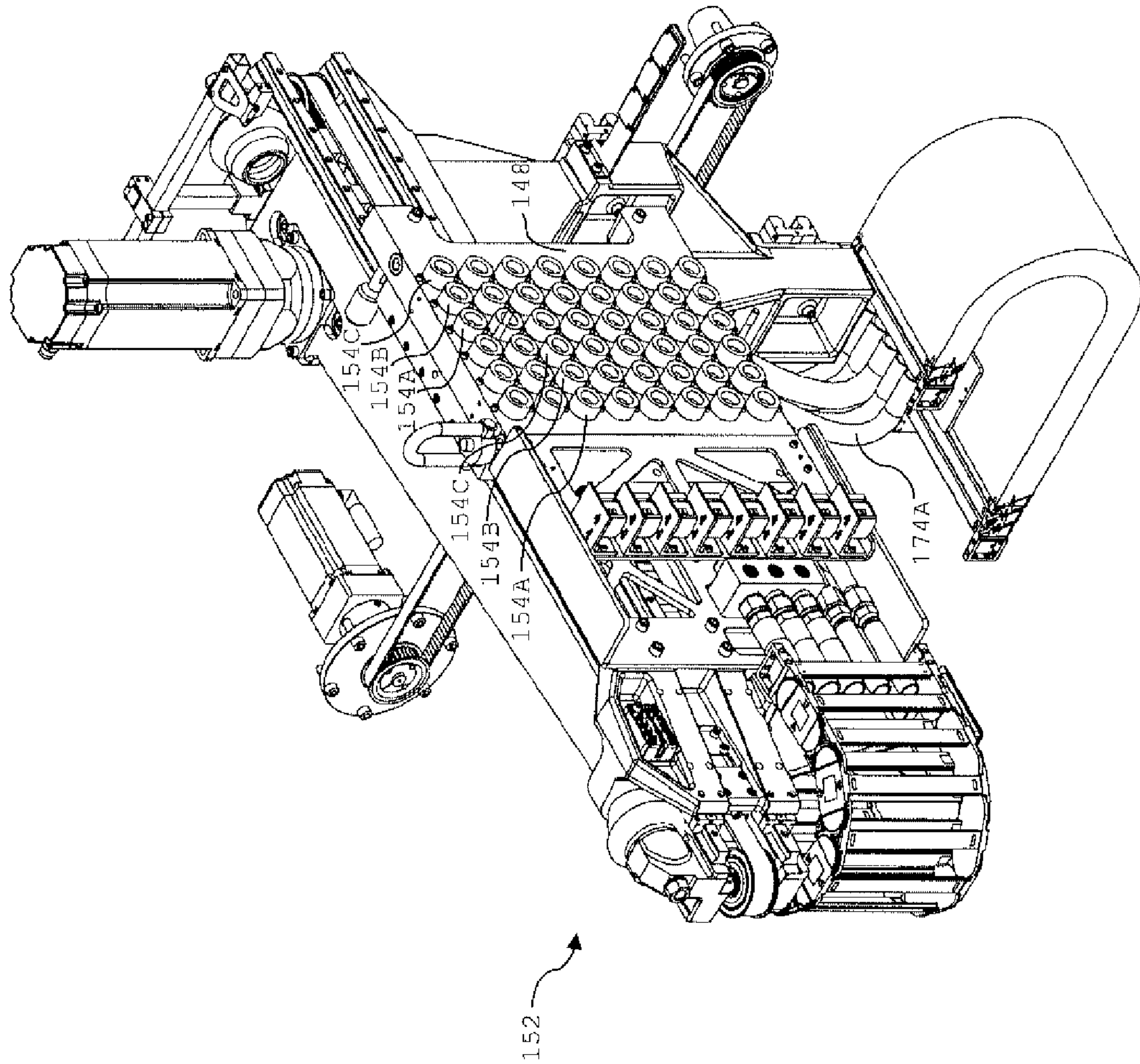


FIG. 3

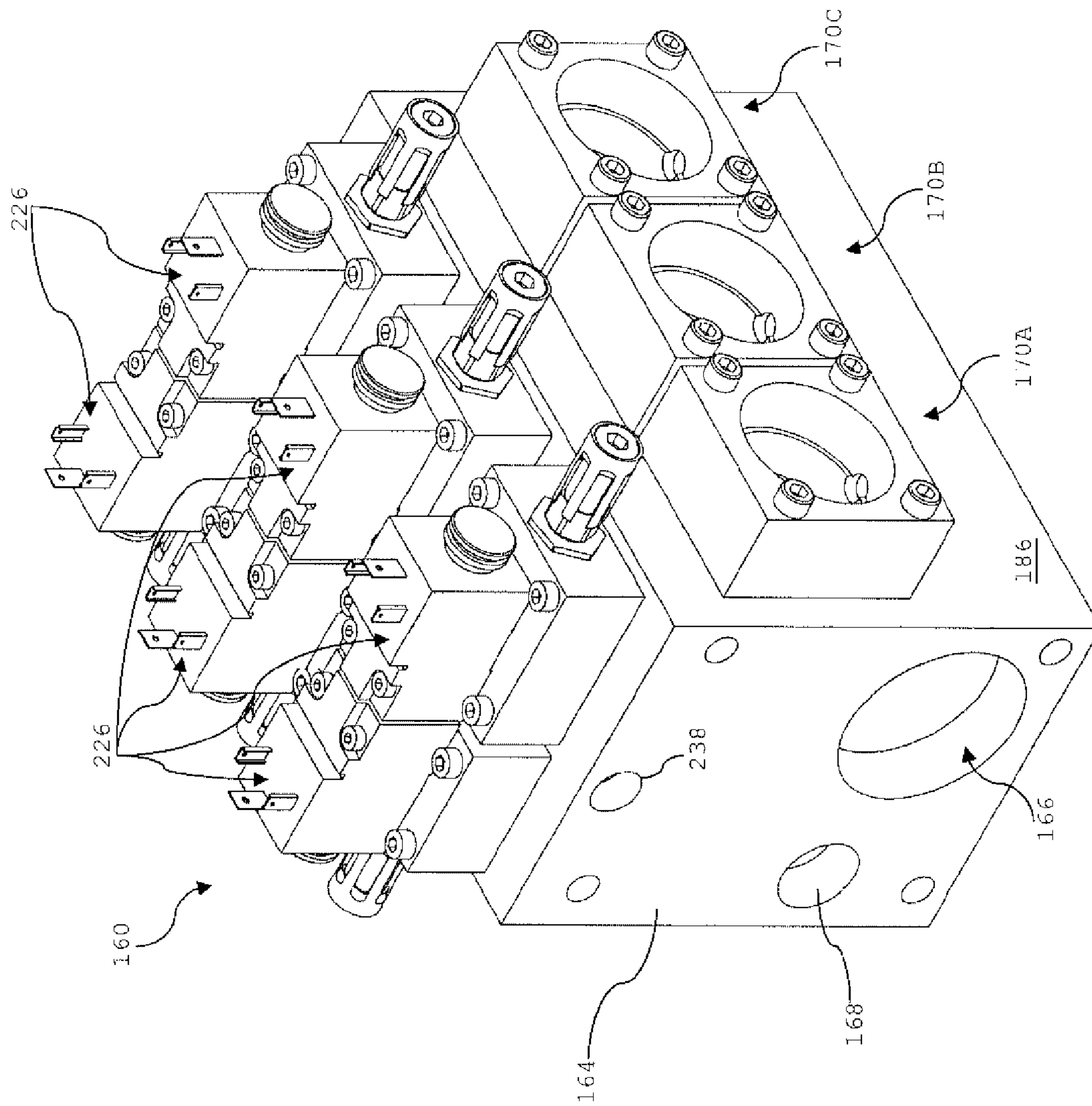


FIG. 4

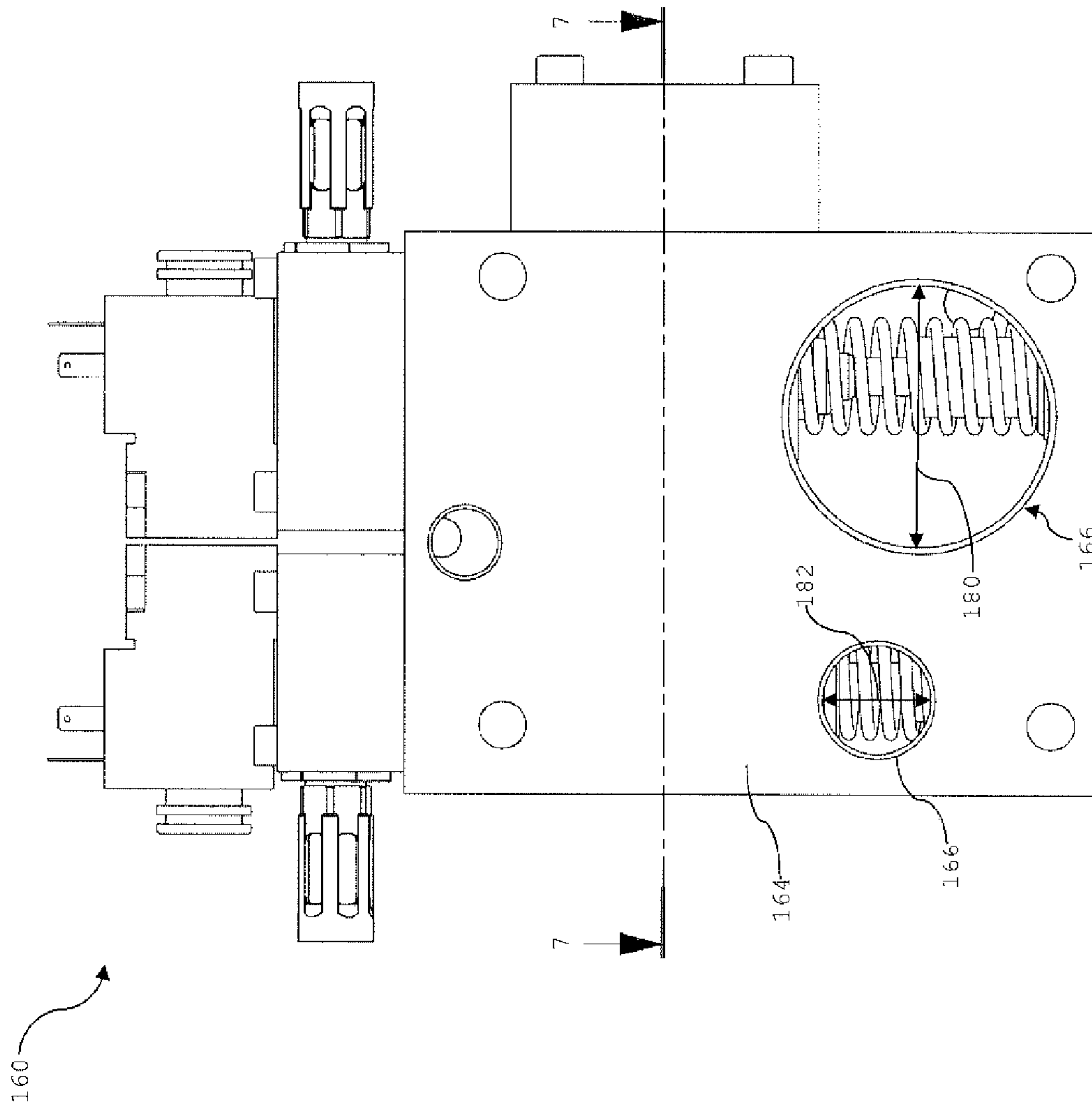


FIG. 5

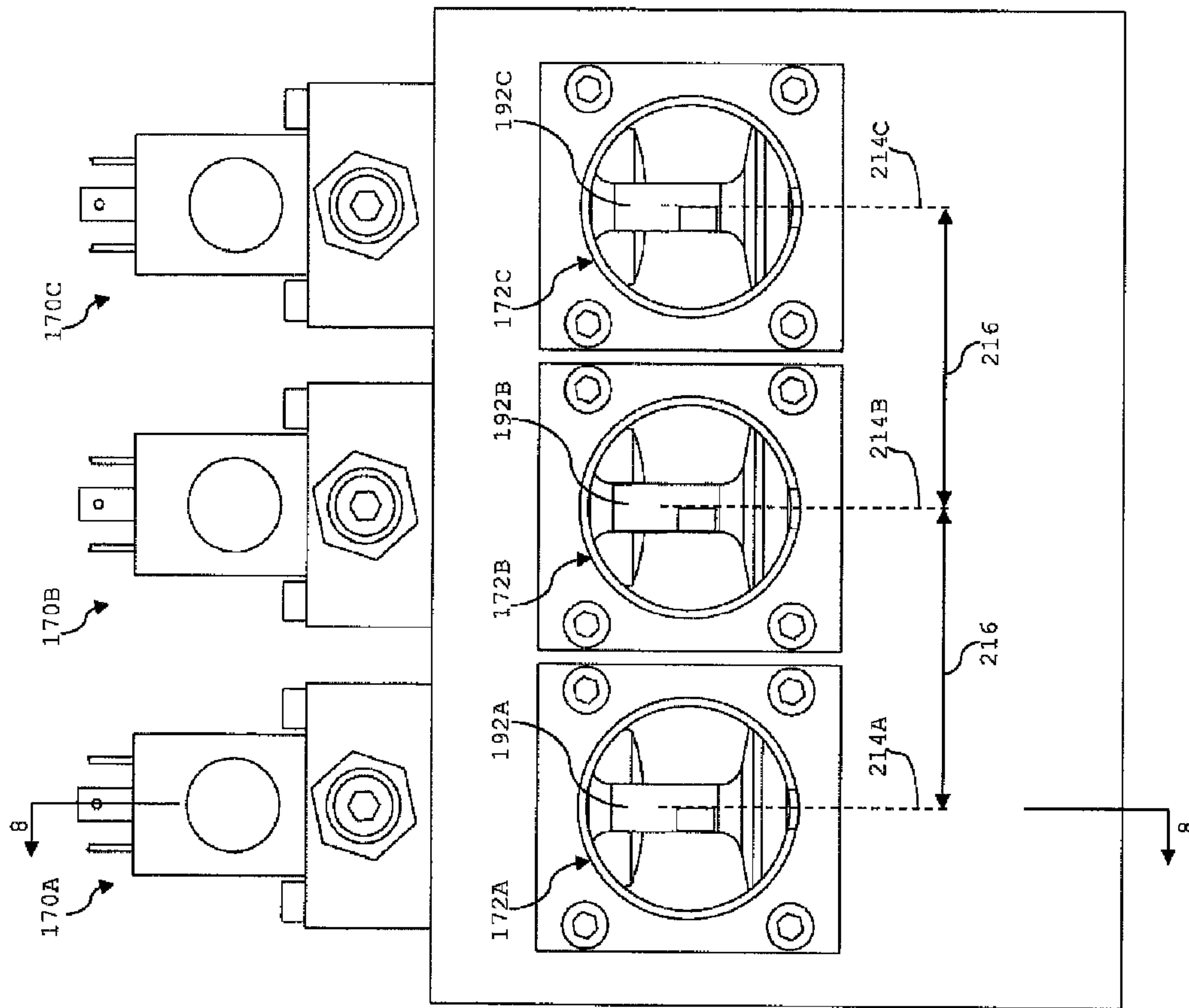


FIG. 6

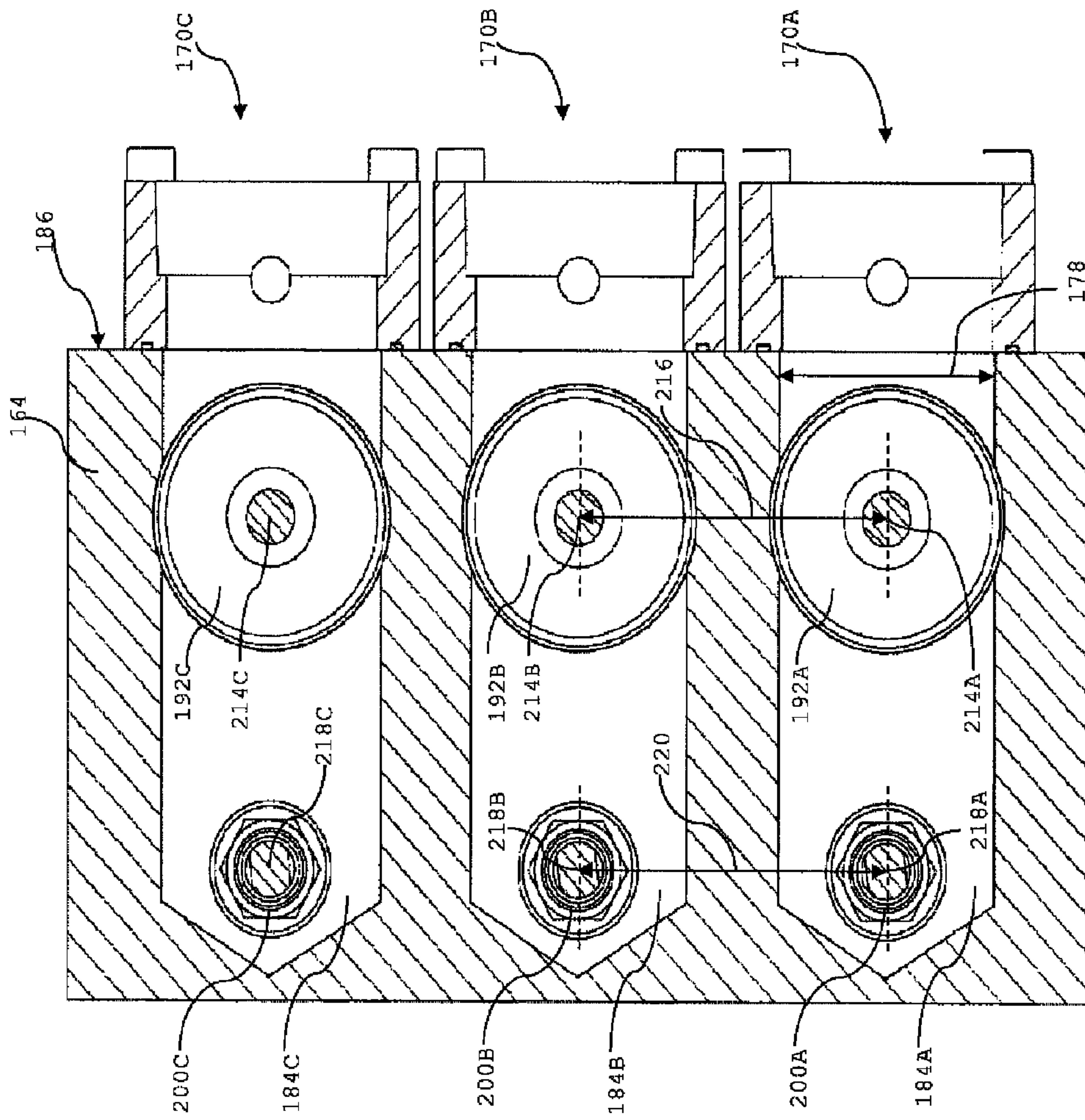


FIG. 7

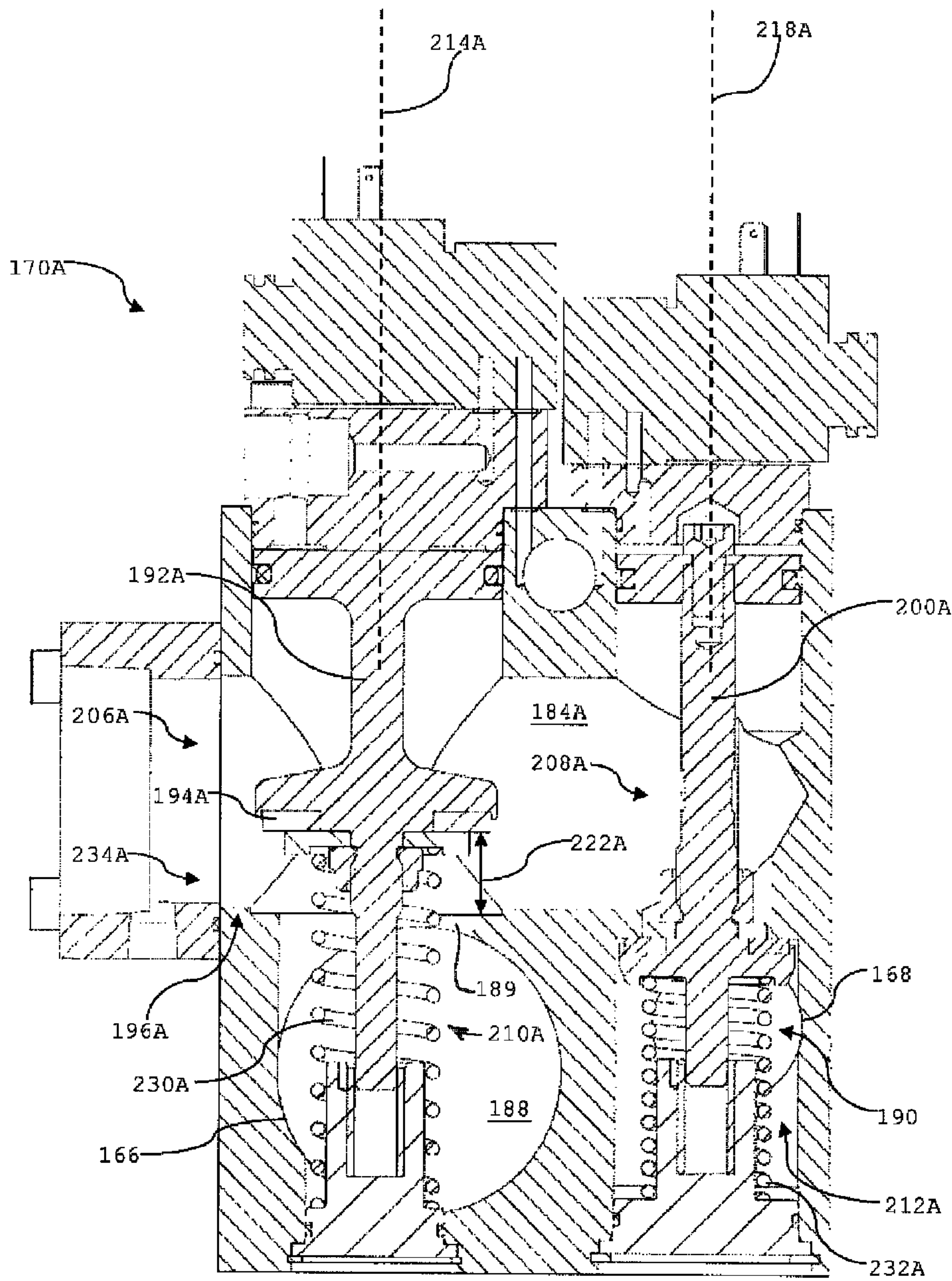


FIG. 8

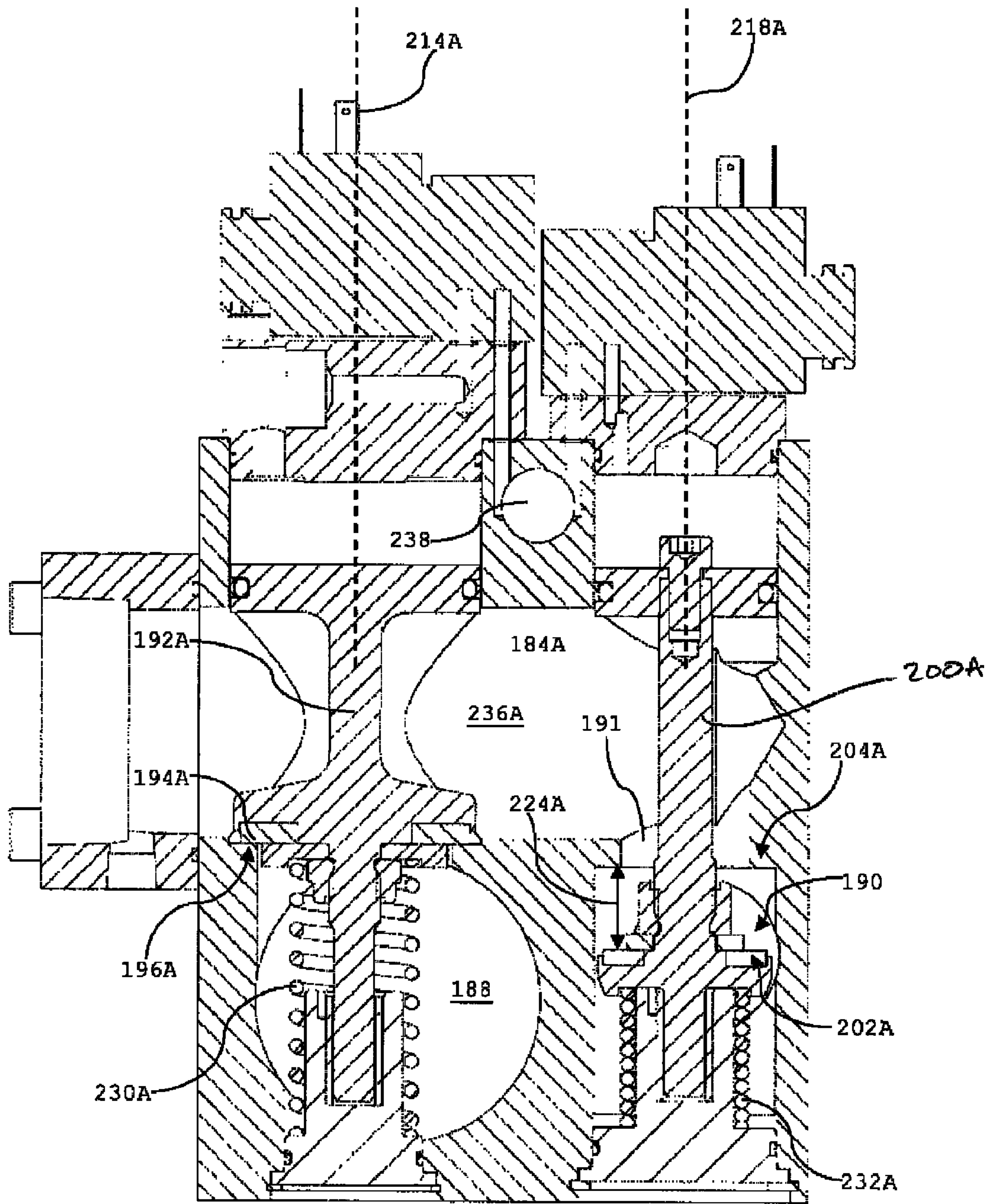


FIG. 9

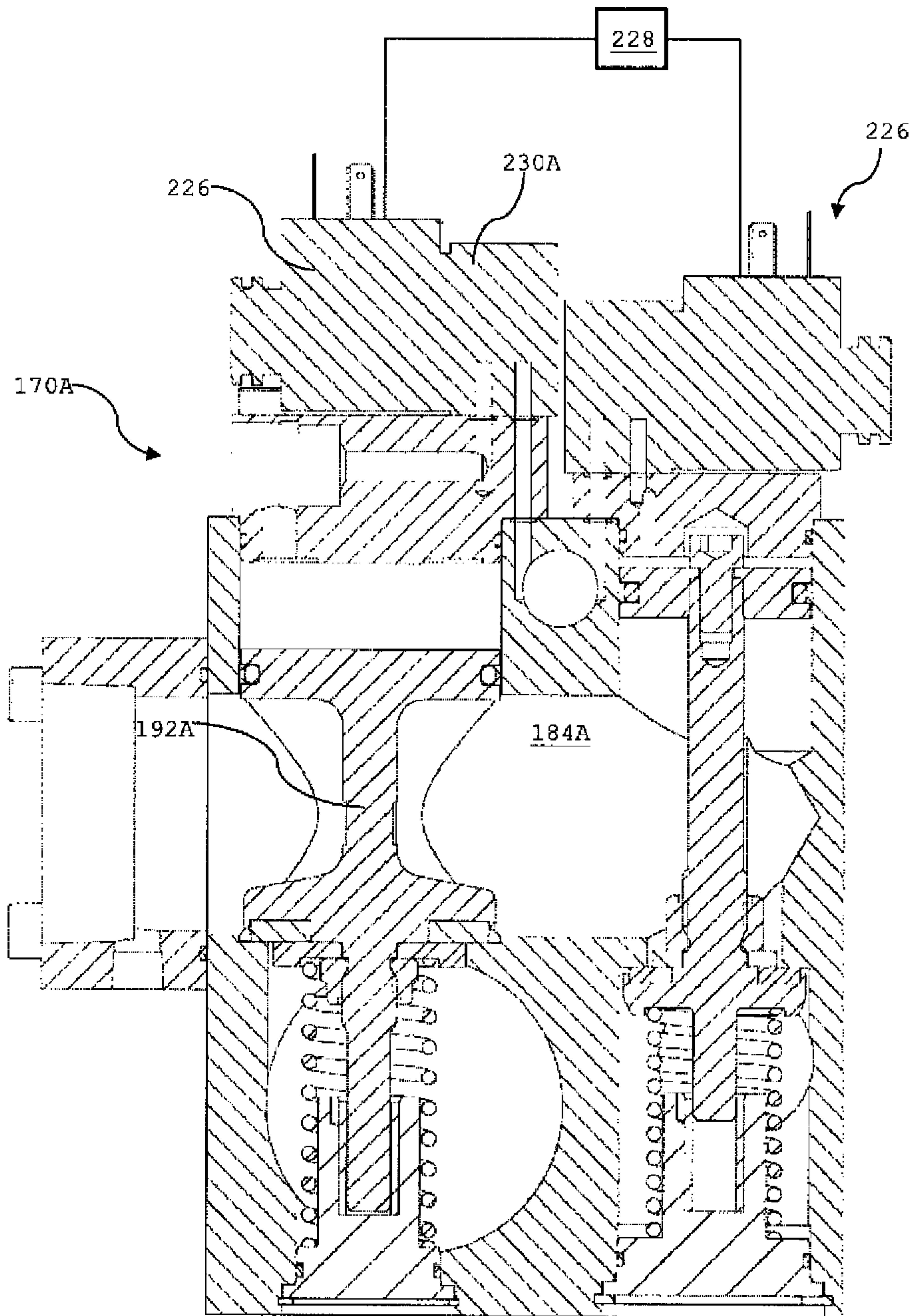


FIG. 10

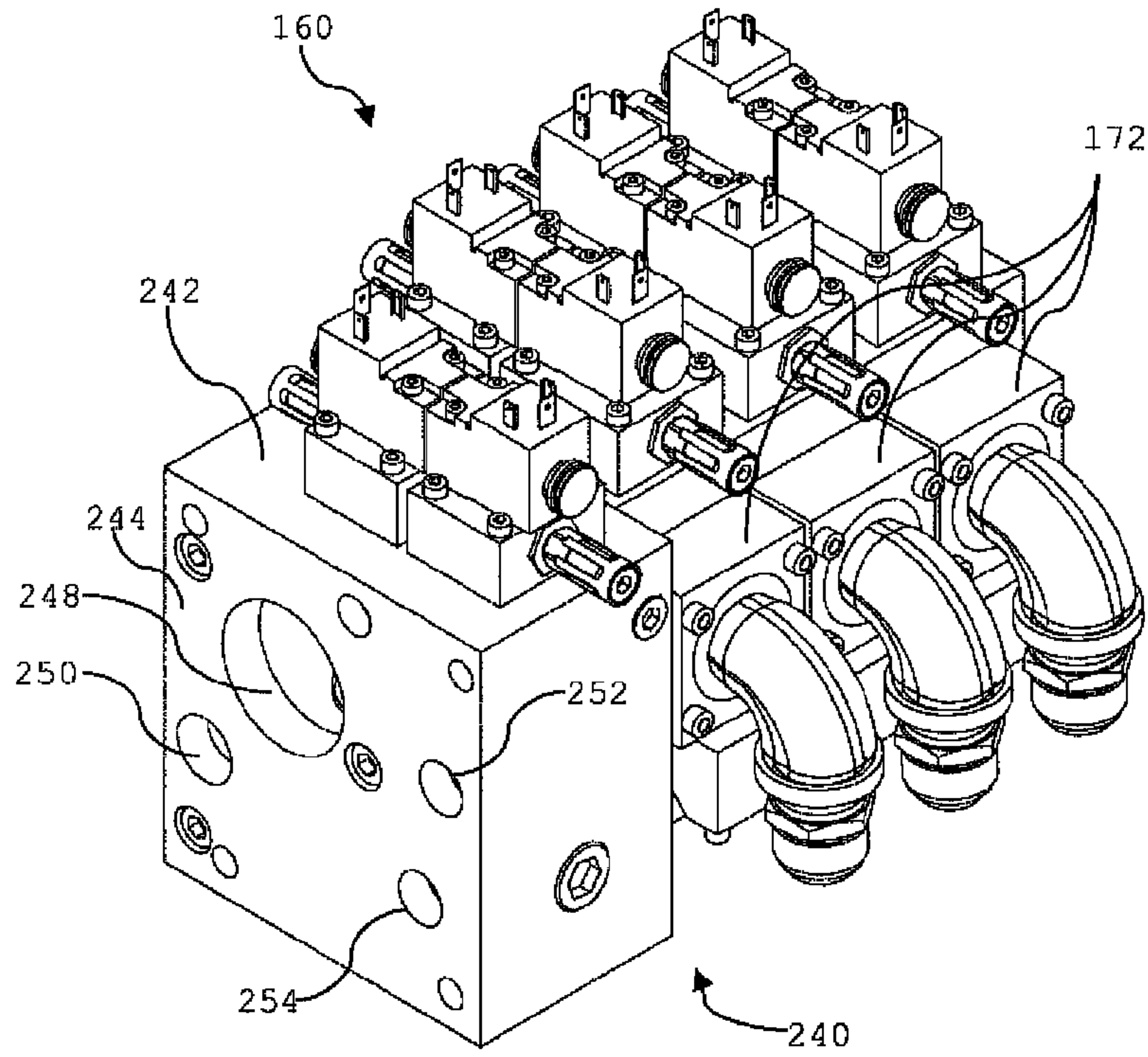


FIG. 11

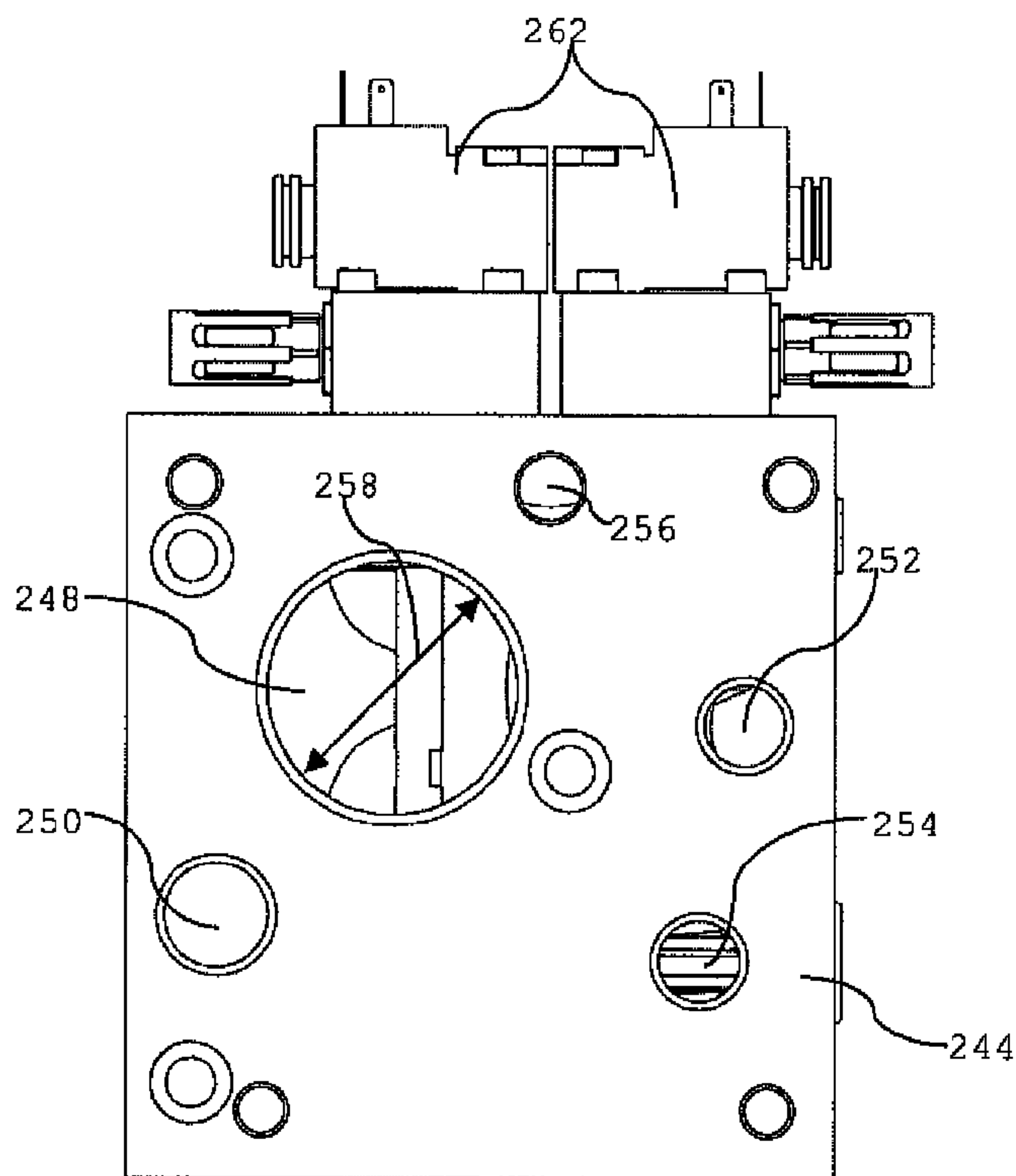


FIG. 12

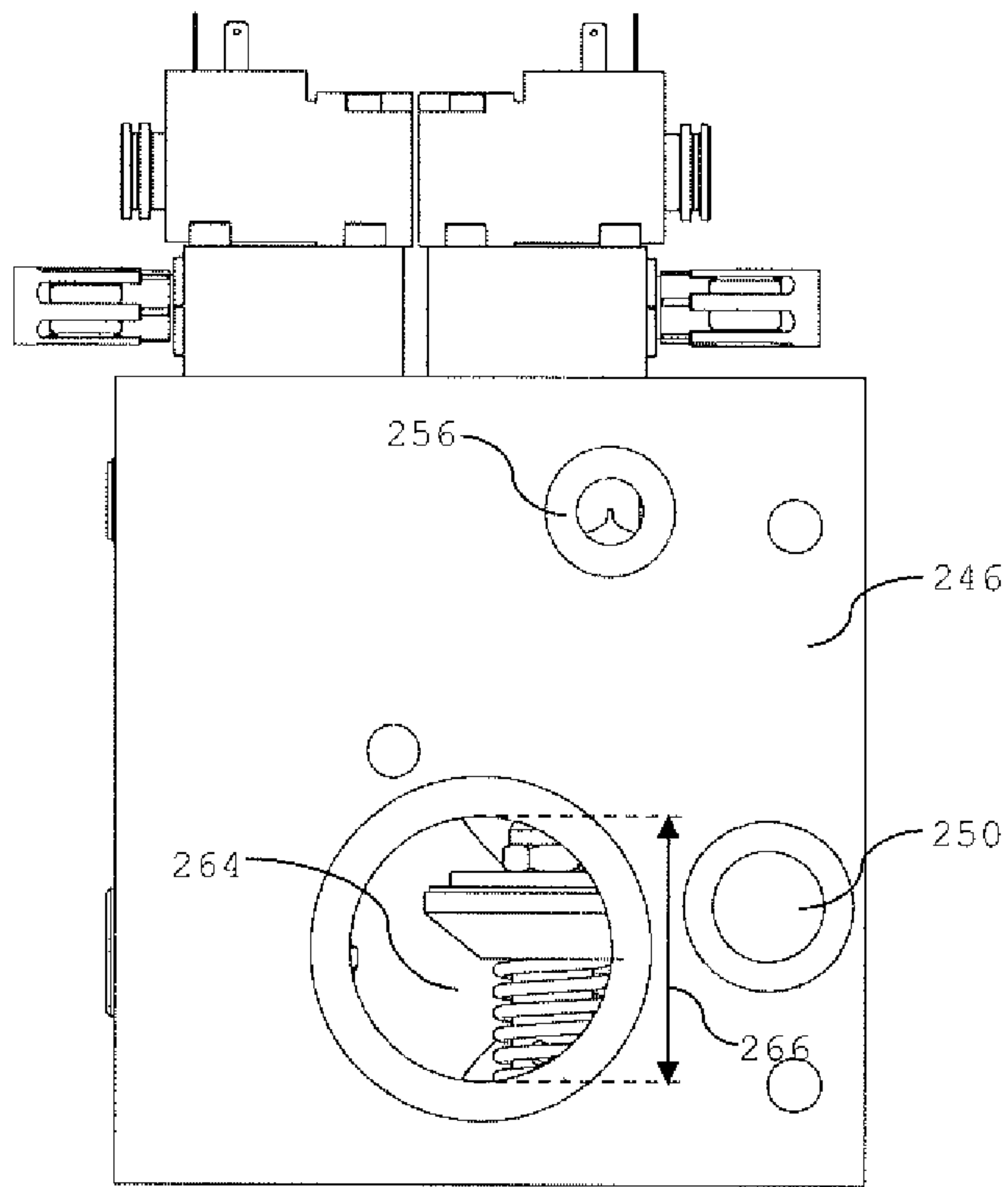


FIG. 13

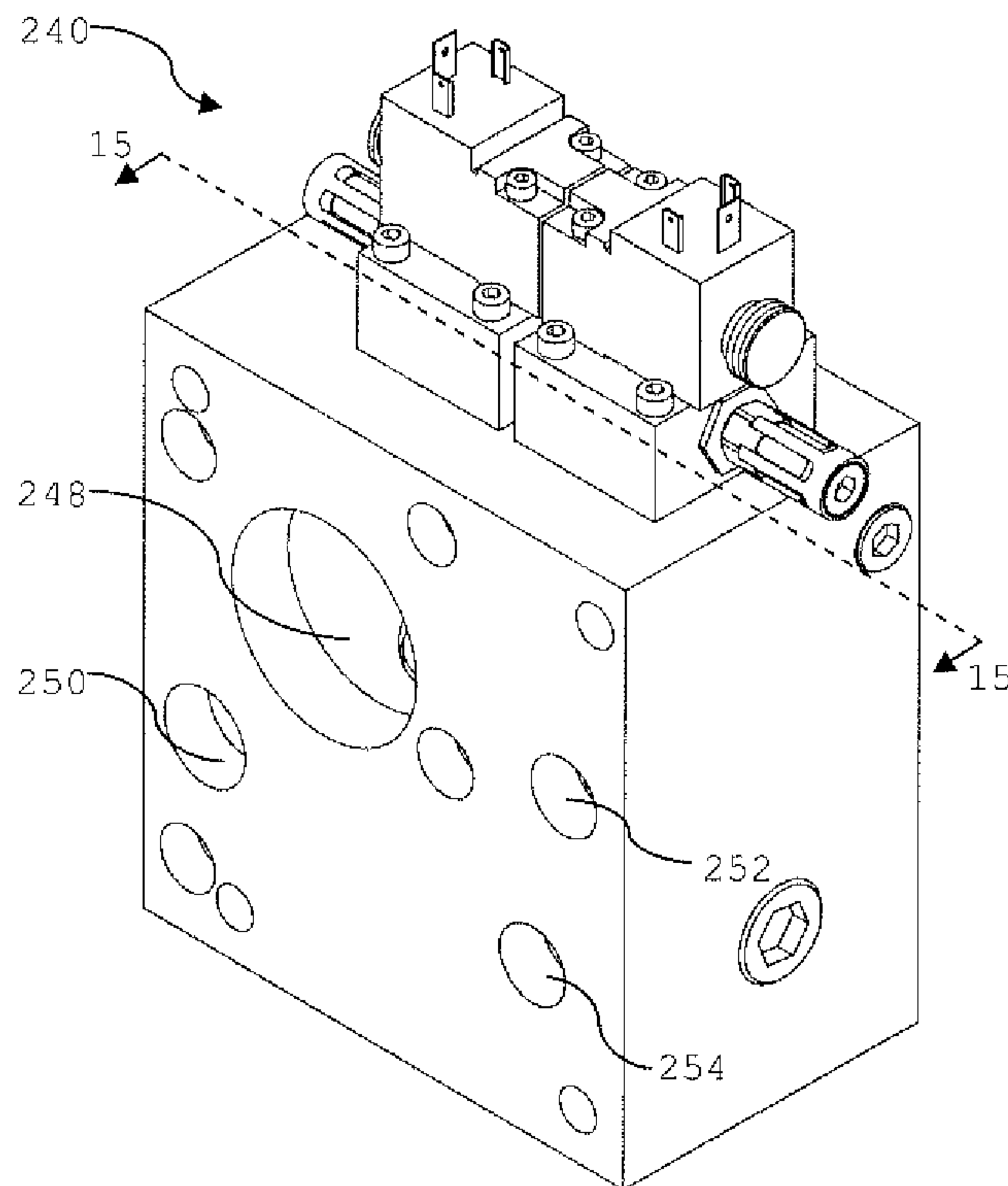


FIG. 14

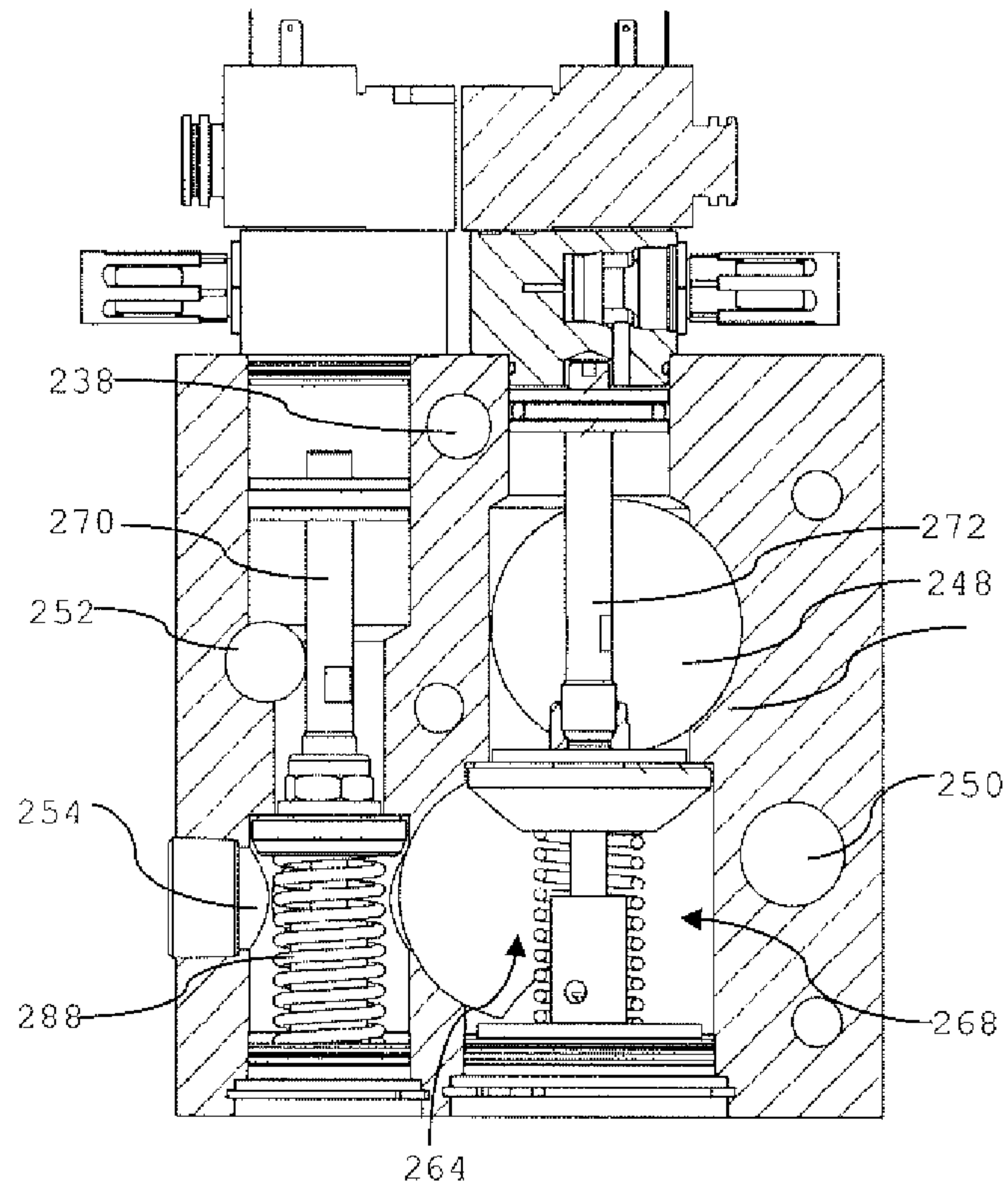


FIG. 15

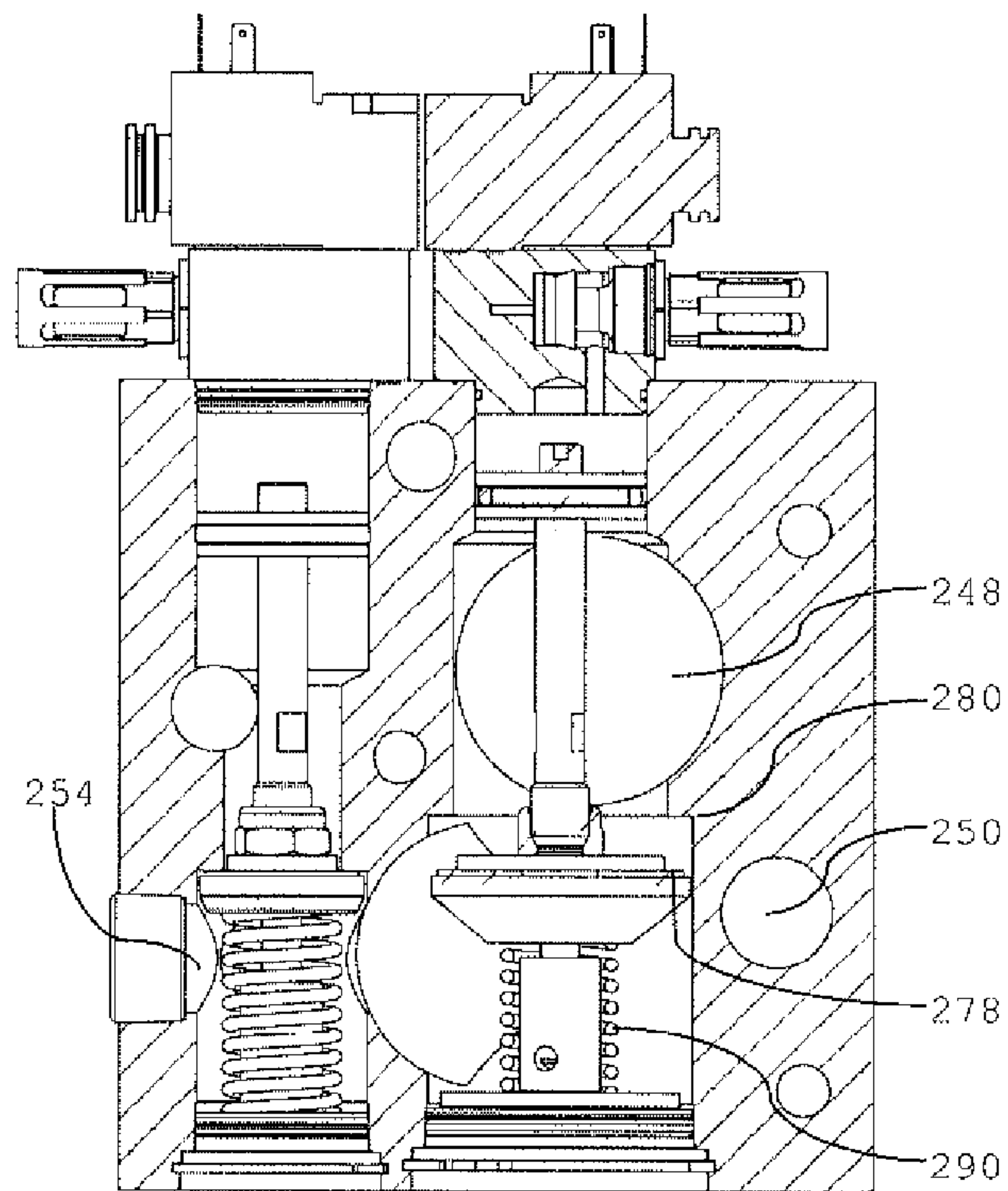


FIG. 16

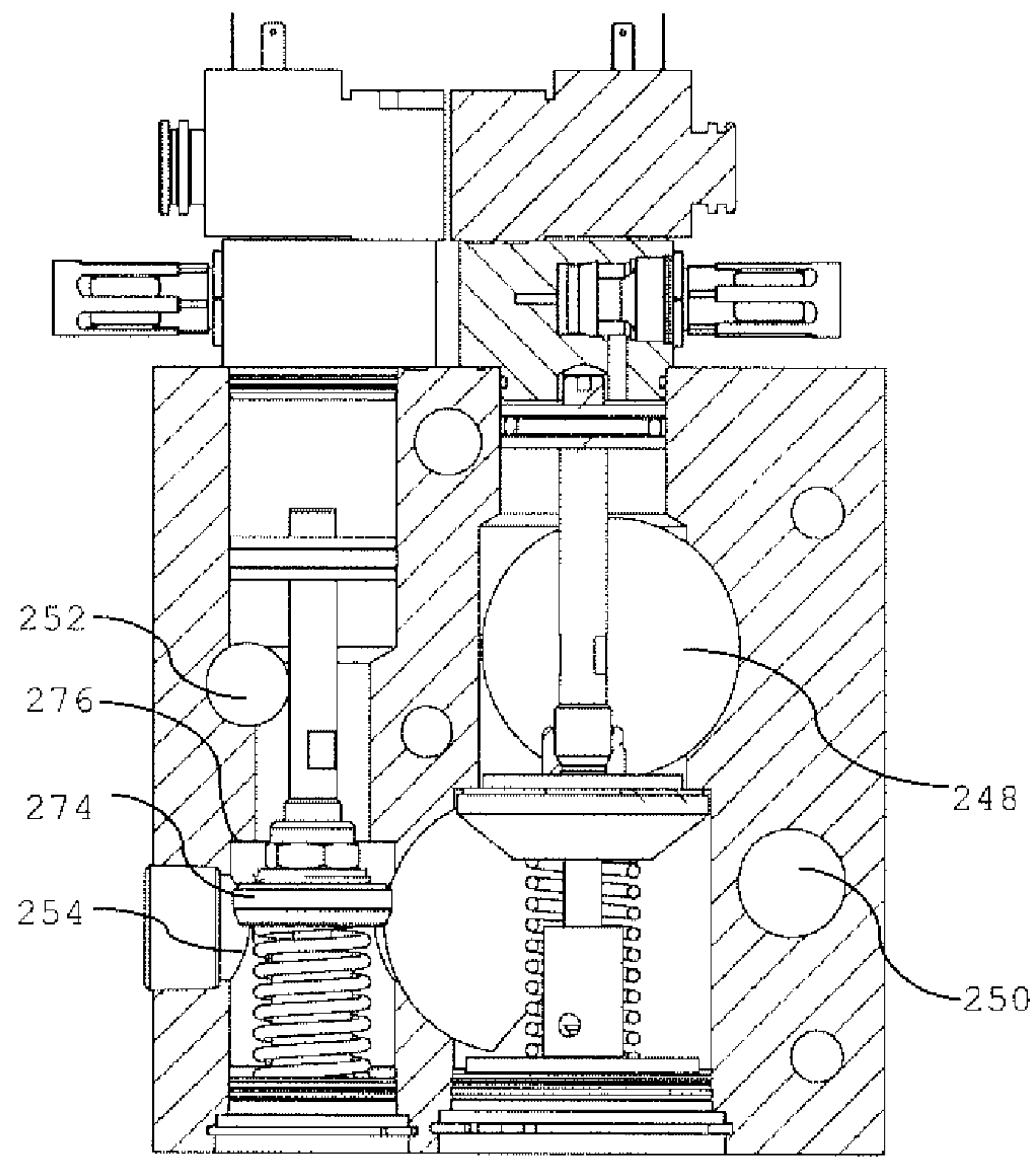


FIG. 17

VALVE ASSEMBLY FOR AN INJECTION MOLDING MACHINE

This application claims the benefit of Provisional Application Ser. No. 61/773,457, filed Mar. 6, 2013, which is hereby incorporated herein by reference.

FIELD

The disclosure relates to injection molding machines and valve assemblies for use with part handling apparatuses used with injection molding machines.

BACKGROUND

U.S. Pat. No. 4,836,767 (Schad) relates to an apparatus for producing molded plastic articles which is capable of simultaneously producing and cooling the plastic articles. The apparatus has a stationary mold half having at least one cavity, at least two mating mold portions, each having at least one core element, mounted to a movable carrier plate which aligns a first one of the mating mold portions with the stationary mold half and positions a second of the mating mold portions in a cooling position, a device for cooling the molded plastic article(s) when in the cooling position, and a device for moving the carrier plate along a first axis so that the aligned mold portion abuts the stationary mold half and the second mating mold portion simultaneously brings each plastic article(s) thereon into contact with the cooling device. The carrier plate is also rotatable about an axis parallel to the first axis to permit different ones of the mating mold portions to assume the aligned position during different molding cycles.

U.S. Pat. No. 6,299,431 (Neter) discloses a rotary cooling station to be used in conjunction with a high output injection molding machine and a robot having a take-out plate. A high speed robot transfers warm preforms onto a separate rotary cooling station where they are retained and internally cooled by specialized cores. The preforms may also be simultaneously cooled from the outside to speed up the cooling rate and thus avoid the formation of crystallinity zones. Solutions for the retention and ejection of the cooled preforms are described. The rotary cooling station of the present invention may be used to cool molded articles made of a single material or multiple materials.

U.S. Pat. No. 6,391,244 (Chen) discloses a take-out device for use with a machine for injection molding plastic articles such as PET preforms. The take-out device has a plurality of cooling tubes that receive hot preforms from the molding machine, carry them to a position remote from the molds of the machine for cooling, and then eject the cooled preforms onto a conveyor or other handling apparatus. The preforms are retained within the cooling tubes by vacuum pressure, but are then ejected by positive air pressure. A retaining plate spaced slightly outwardly beyond the outer ends of the cooling tubes is shiftable into a closed position in which it momentarily blocks ejection of the preforms during the application positive air pressure, yet allows them to be dislodged slightly axially outwardly from the tubes. Such slight dislodging movement is inadequate to vent the air system to atmosphere such that sufficient dislodging air pressure remains in tubes where the preforms might otherwise tend to stick and resist ejection. After the momentary delay, the plate is shifted to an open position in which all of the dislodged preforms are freed to be pushed out of the tubes by the air pressure. Preferably, the retaining plate is provided with specially shaped holes having pass-through portions that become aligned with the tubes when the plate is in its open position, and smaller

diameter blocking portions that become aligned with the tubes when the plate is in its closed position. The smaller diameter blocking portions exceed the diameter of the neck of the preforms but are smaller in diameter than the flanges of the preforms such that surface areas around the blocking portions overlie the flanges to block ejection of the preforms as they undergo their dislodging movement.

EP Pat. No. 1515829 (Unterlander) relates to a method and apparatus for cooling molded plastic articles after molding is finished. In particular, the disclosed invention relates to method and apparatus for a post mold cooling ("PMC") device having at least two opposed faces. The method and apparatus are, according to the inventors, particularly well suited for cooling injection molded thermoplastic polyester polymer materials such as polyethylene terephthalate ("PET") preforms.

SUMMARY

This summary is intended to introduce the reader to the more detailed description that follows and not to limit or define any claimed or as yet unclaimed invention. One or more inventions may reside in any combination or sub-combination of the elements or process steps disclosed in any part of this document including its claims and figures.

According to some aspects of the teaching disclosed herein a valve assembly for use with a part handling apparatus having at least two sets of receivers may include a housing having a first tooling port for fluid communication with a first set of receivers on the part handling apparatus and a second tooling port for fluid communication with a second set of receivers on the part handling apparatus.

A first vacuum channel may extend through the housing and may provide fluid communication between the first tooling port and a vacuum source. A first vacuum closure member may be moveable between an open position, in which the first vacuum channel is open, and a closed position, in which the first vacuum channel is blocked, to selectably permit fluid communication between the first tooling port and the vacuum source.

A first pressure channel may extend through the housing and may provide fluid communication between the first tooling port and a pressurized fluid source. A first pressure closure member may be moveable between an open position, in which the first pressure channel is open, and a closed position, in which the first pressure channel is blocked, to selectably permit fluid communication between the first tooling port and the pressurized fluid source. The first pressure closure member may be moveable independently from the first vacuum closure member.

A second vacuum channel may extend through the housing and may provide fluid communication between the second tooling port and the vacuum source. A second vacuum closure member may be moveable between an open position, in which the second vacuum channel is open, and a closed position, in which the second vacuum channel is blocked, to selectably permit fluid communication between the second tooling port and the vacuum source.

A second pressure channel may extend through the housing and may provide fluid communication between the second tooling port and the pressurized fluid source. A second pressure closure member may be moveable between an open position, in which the first pressure channel is open, and a closed position, in which the second pressure channel is blocked, to selectably permit fluid communication between the second tooling port and the pressurized fluid source. The

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second pressure closure member may be moveable independently from the second vacuum closure member.

The first vacuum closure member may be moveable independently from the second vacuum closure member.

The housing may also include a vacuum port. The first vacuum channel may extend between the vacuum port and the first tooling port. The second vacuum channel may extend between the vacuum port and the second tooling port.

The first vacuum closure member may be the only closure member operable to block the first vacuum channel between the vacuum port and the first tooling port.

The second vacuum closure member may be the only closure member fluidly connected between the vacuum port and the second tooling port.

A vacuum header may be disposed within the housing and may extend from and be in fluid communication with the vacuum port. The vacuum header may include a portion of both the first and second vacuum channels.

The housing may include a pressure port. The first pressure channel may extend between the pressure port and the first tooling port and the second pressure channel may extend between the pressure port and the second tooling port.

A pressure header may be disposed within the housing and may extend from and be in fluid communication with the pressure port. The pressure header may include a portion of both the first and second pressure channels.

A first internal chamber may be disposed within the housing and may form part of the first vacuum channel. The first internal chamber may be in fluid communication with first tooling port and may include a first vacuum opening providing fluid communication between the vacuum header and the first internal chamber. When the first vacuum closure member is in the closed position the first vacuum closure member may seal the first vacuum opening.

The first internal chamber further may include a first pressure opening providing fluid communication between the pressure header and the first internal chamber. When the first pressure closure member is in the closed position the first pressure closure member may seal the first pressure opening.

A second internal chamber may be spaced apart from the first internal chamber and may be disposed within the housing. The second internal chamber may form part of the second vacuum channel, may be in fluid communication with the second tooling port, and may comprising a second vacuum opening providing fluid communication between the vacuum header and the second internal chamber. When the second vacuum closure member is in the closed position the second vacuum closure member may seal the second vacuum opening.

The second internal chamber may also include a second pressure opening providing fluid communication between the pressure header and the second internal chamber. When the second pressure closure member is in the closed position the second pressure closure member may seal the second pressure opening.

The first vacuum opening may define a first vacuum opening fluid flow area and the first pressure opening may defined a first pressure opening fluid flow area, and the first vacuum opening fluid flow area may be at least 200% larger than the first pressure opening fluid flow area.

A first vacuum actuator may be drivingly connected to the first vacuum closure member and a first pressure actuator drivingly may be connected to the first pressure closure member. The first vacuum actuator may be actuatable independently from the first pressure actuator.

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The first vacuum closure member may be translatable along a first vacuum axis between the open and closed positions.

The first pressure closure member may be translatable along a first pressure axis between the open and closed positions, and the first vacuum axis may be generally parallel to and spaced apart from the first pressure axis.

The second vacuum closure member may be translatable along a second vacuum axis between its open and closed positions. The second vacuum axis may be generally parallel to and spaced apart from the first vacuum axis.

The housing may be of unitary, integrally formed one-piece construction.

The first vacuum channel may be sized to accommodate a volumetric flow rate of between about 100 liters per minute and about 750 liters per minute.

A vacuum selector valve may be disposed in fluid communication between the vacuum source and the first tooling port.

According to another broad aspect of the teachings described herein, a part handling assembly for use with an injection molding machine may include a part handling apparatus having at least a first set of receivers for receiving a first set of molded articles and a second set of receivers for receiving a second set of molded articles. The part handling assembly may also include the valve assembly described above.

DRAWINGS

The drawings included herewith are for illustrating various examples of articles, methods, and apparatuses of the teaching of the present specification and are not intended to limit the scope of what is taught in any way.

In the drawings:

FIG. 1 is a back perspective view of an injection molding machine;

FIG. 2 is a front view of an exemplary article formed by the machine of FIG. 1;

FIG. 2A is a top view of the article of FIG. 2;

FIG. 2B is a cross-sectional view of the article of FIG. 2A, taken along the lines 2B-2B;

FIG. 3 is a perspective view of a portion of the machine of FIG. 1, showing part handling features in greater detail;

FIG. 4 is a perspective view of a valve assembly;

FIG. 5 is an end view of the valve assembly of FIG. 4;

FIG. 6 is a front view of the valve assembly of FIG. 4;

FIG. 7 is a section view of the valve assembly of FIG. 4, taken along line 7-7 in FIG. 5;

FIG. 8 is section view of a portion of the valve assembly of FIG. 4 with a vacuum closure member open, taken along line 8-8 in FIG. 4;

FIG. 9 is the section view of FIG. 8 with a pressure closure member open;

FIG. 10 is the section view of FIG. 8 with the vacuum and pressure closure members closed;

FIG. 11 is a perspective view of the valve assembly of FIG. 4 including a vacuum selector valve;

FIG. 12 is a front of the vacuum selector valve of FIG. 11;

FIG. 13 is a rear view of the vacuum selector valve of FIG. 11;

FIG. 14 is a perspective view of the vacuum selector valve of FIG. 11;

FIG. 15 is a cross-sectional view of the vacuum selector valve of FIG. 11, taken along line 15-15 in FIG. 14;

FIG. 16 is the cross-sectional view of FIG. 15, with a high vacuum actuator in an open position; and

FIG. 17 is the cross-sectional view of FIG. 15, with a low vacuum actuator in an open position.

DETAILED DESCRIPTION

Various apparatuses or processes will be described below to provide an example of an embodiment of each claimed invention. No embodiment described below limits any claimed invention and any claimed invention may cover processes or apparatuses that differ from those described below. The claimed inventions are not limited to apparatuses or processes having all of the features of any one apparatus or process described below or to features common to multiple or all of the apparatuses described below. It is possible that an apparatus or process described below is not an embodiment of any claimed invention. Any invention disclosed in an apparatus or process described below that is not claimed in this document may be the subject matter of another protective instrument, for example, a continuing patent application, and the applicants, inventors or owners do not intend to abandon, disclaim or dedicate to the public any such invention by its disclosure in this document.

Referring to FIG. 1, an example of an injection molding machine 100 includes a base 102, with a stationary platen 104a and a moving platen 104b mounted to the base and coupled together via tie bars 106 (some of which are not illustrated in FIG. 1). The moving platen 104b can translate towards and away from the stationary platen 104a along a machine axis 108. A mold 110 is formed between the platen. The mold is defined at least in part by a first mold half 110a mounted to the stationary platen 104a, and a second mold half 110b mounted to the moving platen 104b.

In the example illustrated, the injection molding machine 100 is shown set up for molding preforms that can be used as input material for subsequent processing, for example, a blow molding operation to produce beverage containers. With reference to FIG. 2, an exemplary preform 112 comprises a generally elongate tubular article extending along a preform axis 114, and having opposing open and closed ends 116, 118. A threaded portion 120 for receiving a closure may be provided adjacent the open end 116. A radially outwardly extending annular flange 122 may be disposed adjacent the threaded portion 120, with the threaded portion 120 disposed axially between the open end 116 and the flange 122. The preforms have an inner surface 124 that can include a generally cylindrical inner wall portion 124a along the axial extent of the preform (between the open and closed ends), and a generally concave inner end portion 124b at the closed end. The preforms 112 have an outer surface 126 spaced apart from the inner surface 124 that can include a generally cylindrical outer wall portion 126a along the axial extent of the preform and a convex outer end portion 126b at the closed end. The spacing between the inner and outer surfaces 124, 126 generally defines a preform wall thickness 128.

With reference again to FIG. 1, an injection unit 130 is mounted to the base 102 for injecting resin or other mold material into the mold 110 to form a molded article. In the example illustrated for producing the preforms, the first mold half 110a (attached to the stationary platen 104a) can comprise a cavity side of the mold having recesses (or mold cavities—not shown) for forming the outer surface of the preforms 112. The second mold half 110b can comprise a core side of the mold having mold core pins 132 for insertion into the mold cavities and forming the inner surface 124 of the preforms 112. In the example illustrated, the machine 100 has an equal quantity of mold cavities and mold pins, this quantity defining the cavitation number of the mold 110. Typical mold

cavitation numbers include 16, 32, 48, 96 or more. In the example illustrated, the mold cavitation number is 16, and the mold has 16 mold cavities and 16 mold pins, arranged in a 2×8 matrix.

The injection molding machine 100 is, in the example illustrated, provided with a part-handling assembly for moving and/or treating articles formed in the mold 110 of the machine 100. A part-handling assembly may include one or more part handling apparatuses, including, for example a cooling shell, a take-out plate, an end station, a robot, a conveyor and any other suitable members.

In the illustrated example, the part-handling assembly 140 includes a rotary cooling shell 142 having a plurality of sides, each side rotatable together with the cooling shell about a shell axis 144. In the example illustrated, the shell axis 144 is generally horizontal and perpendicular to the machine axis 108. The cooling shell 142 has (in the example illustrated) two generally planar sides including a first side 146a and a second side 146b, the two sides generally parallel and on opposed sides of the axis 144. At least one side of the cooling shell 142 is provided with a plurality of receivers for receiving and handling the preforms, and the shell receivers can be in the form of pins.

In the illustrated example, the part-handling assembly 140 also includes a take-out plate 148 that is movable between the mold 110 and the cooling shell 142 for transferring articles therebetween. The take-out plate 148 generally transfers articles from the mold 110 to a position outside the mold 110 for engagement by the shell receivers, in the form of pins 150, on the cooling shell 144. The take-out plate 148 is joined to a robot 152 that can translate the take-out plate 148 between at least one advanced position in which the take-out plate 148 is disposed between the mold halves 110a, 110b and at least one retracted position in which the take-out plate 148 is clear of the mold 110.

Referring to FIG. 3, the take-out plate has a quantity of receivers for receiving molded articles from within the mold 110. In the illustrated example, the receivers include a plurality of transfer tubes 154 for receiving molded articles from the mold core pins 132. The quantity of transfer tubes 154 can be equal to or greater than the cavitation number of the mold 110. In the example illustrated, the quantity of transfer tubes 154 provided on the take-out plate 148 comprises three sets of 16 tubes each—first set tubes 154a, second set tubes 154b, and third set tubes 154c, for a total of 48 transfer tubes 154. The first set transfer tubes 154a of the take-out plate 148 are, in the example illustrated, spaced apart from each other in a tube pattern of eight rows and two columns that matches the pin pattern. The tubes of the second and third transfer tube sets 154b, 154c are similarly spaced apart from each other in the same tube pattern of eight rows and tubes columns, and in the example illustrated, are interlaced with first set tubes 154a.

In the example illustrated, the take-out plate 148 can be moved to a first advanced position in which the first set tubes 154a are aligned with the mold core pins 132 to receive preforms therefrom. The take-out plate 148 can also be moved to a second advanced position in which the second set tubes 154b are aligned with the mold core pins 132, and to a third advanced position in which the third set tubes 154c are aligned with the mold core pins 132.

The take-out plate 148 can also be moved to at least one retracted position for selectively aligning the transfer tubes 154a-c with pins of the shell 142 at a load station. In the example illustrated, the take-out plate 148 is movable relative to the cooling shell 142 to one retracted position in which the 48 transfer tubes are each simultaneously aligned with respective ones of the 48 cooling pins 150 of a shell side 146a

or **146b** in the load station. The first set tubes **154a** are aligned with the first set cooling pins, the second set tubes **154b** are aligned with the second set cooling pins, and the third set tubes **154c** are aligned with the third set cooling pins.

The transfer tubes **154** can be provided with any suitable means or mechanism for receiving, retaining and optionally ejecting the molded articles from within the transfer tubes. Optionally, the transfer tubes **154** may also be configured to cool the preforms contained therein, and may themselves be liquid cooled or otherwise cooled. In the illustrated example, each transfer tube **154** is selectably connectable to any suitable vacuum source **156**, and any suitable pressurized fluid (e.g. air) source **158**, to alter the pressure within the transfer tube **154**. When receiving molded articles from the mold pins **132** the transfer tubes **154** can be connected to the vacuum source whereby pressure within the transfer tubes **154** is reduced and molded articles can be sucked of the mold pins **132** and into the tubes **154**. After transferring the preforms into the tubes **154**, the vacuum can be maintained, at the same level or at a different level (for example, a lower level of vacuum) to retain the molded articles within the transfer tubes **154** while the take-out plate **148** is removed from the mold area.

To eject the molded articles from the transfer tubes **154** the vacuum suction can be replaced with a supply or blast of pressurized air, whereby the molded articles can be ejected from the transfer tubes **154**. Parts ejected from the transfer tubes may be transferred to the cooling shell **142** (in the example illustrated) or may be dropped to a conveyor belt or other conveyance means.

Optionally, the supply of vacuum and pressurized air to the transfer tubes **154** may be independently controlled for each set of transfer tubes **154a**, **154b** and **154c**. Such independent control may enable a first vacuum to be applied to the first set of transfer tubes **154a** (e.g. to draw a first set of molded articles into the tubes), while a second lower vacuum is applied to the second or third sets of transfer tubes **154b** and **154c**. This may be desirable when the second and/or third sets of transfer tubes **154b** and **154c** are empty as it may help reduce the amount of ambient air sucked into the vacuum system. This may reduce the required size and/or capacity of the vacuum source **156**. When handling multiple sets of molded articles in respective sets of the transfer tubes **154a-c**, it may be desirable to eject one set of molded articles from its transfer tubes without necessarily having to eject the other set of molded articles from their tubes. Providing independent control of the vacuum and pressurized air supplies to each set of transfer tubes may help facilitate such controlled, selected ejection of a given set of molded articles.

Referring to FIG. 1, in the illustrated example the injection molding machine includes a valve assembly **160** that is configured to regulate the supply of pressurized air and vacuum suction to each set of transfer tubes **154** on the take-out plate **148**. Optionally, additional valve assemblies may be provided to regulate the supply of pressurized air and/or vacuum suction to other groups or sets of receivers on an injection molding machine, including for example retaining pins, cooling pins, and/or cooling tubes provided in a secondary end station **162**. In the example illustrated, the valve assembly **160** is connected in fluid communication between the vacuum source **156**, the pressurized air source **154** and the take-out plate **148**.

Referring to FIG. 4, in the illustrated example the valve assembly **160** includes a housing **164** having at least one vacuum port **166** that is fluidly connectable to the vacuum source **156** using any suitable means, such as a hose, pipe or other conduit, and at least one pressure port **168** that is fluidly

connectable to a pressurized fluid source **158** using any suitable means, such as a hose, pipe or other conduit.

As explained above, in the illustrated example the take-out plate **148** includes three sets of transfer tubes **154a-c**, and the valve assembly includes three valve sub-assemblies **170a**, **170b**, **170c** (one valve assembly **170** corresponding to each set of transfer tubes **154a-c**) operable to independently control the supply of vacuum suction and/or pressurized fluid to each set of transfer tubes **154**. In the illustrated example, the valve sub-assemblies **170a-c** are generally identical and operate in the same manner. Providing identical valve sub-assemblies may help provide consistent performance within each sub-assembly and may help reduce the complexity and/or cost of manufacturing the valve assembly **160**. Alternatively, the valve sub-assemblies need not be identical.

A first valve sub-assembly **170a** is described in greater detail herein, and it is understood that in the example illustrated the second and third valve sub-assemblies **170b** and **170c** include analogous features, identified where appropriate using analogous reference characters with "b" and "c" suffixes respectively, and can operate in an analogous way.

Referring to FIG. 6, the first valve sub-assembly **170a** includes a tooling port **172a** that is fluidly connected to the first set of transfer tubes **154a** on the take-out plate **148** via a hose (hoses **174a** in FIG. 3). While illustrated as generally circular in cross-sectional area, the tooling port **172a** may be of any suitable shape or configuration.

In the illustrated example, the tooling port **172a** can function as an inlet port when providing vacuum suction to the transfer tubes **154a**, and as an outlet port when providing pressurized air to the transfer tubes **154a**. The tooling port **172a** has a tooling port diameter **178a** (FIG. 7) and a corresponding tooling port cross-sectional flow area. The tooling port diameter **178a**, and related area, may be selected to facilitate a desired fluid flow rate through the tooling port **172a** for both the vacuum and pressurized fluid flows. Optionally, the tooling port diameter **178** may be sized so that it is greater than the diameter **180** of the pressure port **168** (FIG. 5), and may be generally equal to the diameter **180** of the vacuum port **166**. Alternatively, the tooling port diameter **178** can be selected so that the flow area of the tooling port **172a** is greater than the flow area of the pressure port **168** and is less than the flow area of the vacuum port **166**. Sizing the tooling port **172a** to accommodate the desired vacuum fluid flow volume may help ensure that the tooling port **172a** can accommodate both the vacuum fluid flow volume and the high pressure fluid flow volume. In the illustrated example, the diameter **178a** of the tooling port **172a** may be between about 10 mm and about 100 mm, or may be greater than 100 mm. The diameter **180** of the vacuum port **166** may be between about 10 mm and about 100 mm, or may be greater than 100 mm. The diameter **182** of the pressure port **168** (FIG. 5) may be between about 5 mm and about 60 mm, or may be greater than 60 mm. Optionally, the diameter **178a** of the tooling port **172a** may be at least 200% of the diameter **182a** of the pressure port **168**, and/or may be between about 80% and about 120%, of the diameter **180** of the vacuum port **166**.

To provide vacuum communication between the vacuum port **166** and the tooling port **172a**, a vacuum channel **234a** (FIG. 9) is provided within the housing **164**. The vacuum channel **234a** can comprise a plurality of sections or portions, including chamber **184a** and vacuum header **188** (described in detail below), that co-operate to provide the channel **234a**. Portions of vacuum channel **234a** may be provided in common with portions of vacuum channels **234b** and **234c**. For example, vacuum header **188** may be common to all of the vacuum channels **234a-c**. The vacuum channel **234** can be

sized to provide a desired volumetric fluid flow rate, which, for example, may be between about 100 liters per minute and about 750 liters per minute.

Referring to FIG. 8, the tooling port 172a is in fluid communication with a corresponding chamber 184a formed within the housing 164. The chamber 184a is selectably connectable in fluid communication with the vacuum source 156 and pressurized fluid source 158 and, in the example illustrated, forms part of the vacuum channel 234a between the tooling port 172a and the vacuum source 156.

To provide air flow communication between the pressure port 168 and the tooling port 172a, a pressure channel 236a (FIG. 9) is provided within the housing 164. The pressure channel 236a can comprise a plurality of sections or portions, including chamber 184a and pressure header 190, that cooperate to provide the channel 236a.

Optionally, the vacuum channel 234a and pressure channel 236a may at least partially overlap with each other and/or share at least one portion in common. In the illustrated example, the chamber 184a forms a portion of both the vacuum channel 234a and the pressure channel 236. Alternatively, the vacuum channel 234a and pressure channel 236 may be mutually exclusive.

Referring to FIG. 7, in the illustrated example, the valve assembly housing 164 is of unitary, integrally formed one-piece construction and the chamber 184a is formed as a blind hole machined in the housing 162 and extending inwardly from a tooling port face 186 of the housing 162. Alternatively, the housing 162 may be of multi-piece construction, and the chambers 184a-c may be formed in any suitable manner.

Referring to FIG. 8, the housing 164 includes a vacuum header 188 extending from the vacuum port 166 and forming part of the vacuum channel 234, and a pressure header 190 extending from the pressure port 168 and forming part of the pressure channel 236. Each header 188, 190 extends along substantially the entire length of the valve assembly housing 164 and extends into each of the three valve sub-assemblies 170a-c. Each chamber 184a-c within the housing 164 is in selectable fluid communication with both the vacuum header 188 and the pressure header 190 thereby providing fluid communication between the chambers 184a-c and the vacuum source 156 and pressurized fluid source 158, respectively. In this configuration, each valve sub-assembly 170a-c is in fluid communication with a common vacuum source 156 and a common pressurized fluid source 158. Connecting each chamber 184a-c to a common vacuum header 188 and a common pressure header 190 may help balance the suction/pressure applied to each set of receivers 154a-c.

To provide selectable communication between the chambers 184a-c and the vacuum and pressure headers 188, 190, each chamber 184a-c includes at least one vacuum opening 189 (FIG. 8) and at least one pressure opening 191 (FIG. 9), which provide fluid communication between the chambers 184a-c and the vacuum and pressure headers 188, 190, respectively, and form part of the vacuum and pressure channels 234, 236. The chambers 184a-c are also provided with at least one moveable closure member to seal each opening 189 and 191. In the illustrated example, each chamber 184a-c is formed to accommodate at least one vacuum closure member and at least one pressure closure member. Optionally, the openings 189 and 191 may be of different cross-sectional area, and the vacuum opening 189 may be larger than the pressure opening 191, and may be between about 150% to about 400% greater or more, and optionally may be at about least 200% greater.

Referring to FIG. 8, in the illustrated example a vacuum closure member 192a in chamber 184a includes a sealing

member 194a (such as a gasket, o-ring or other suitable member) that can contact and seal against a corresponding seat 196a in the chamber 184a. The vacuum closure 192a is moveable between an open position (FIG. 8) in which the vacuum channel 234 is open, and a closed position (FIGS. 9 and 10) in which the vacuum channel 234 is blocked. In the open position the sealing member 194a is spaced apart from the seat 196a thereby providing a fluid passage connecting the chamber 184a, and tooling port 172a, and the vacuum header 188. In the closed position the sealing member 194a contacts the seat 196a and fluidly isolates the chamber 184a from the vacuum header 188.

Similarly, referring to FIG. 9, a pressure closure member 200a includes a sealing member 202a that can contact and seal against a corresponding seat 204a in the chamber 184a. The pressure closure member 200a is moveable between an open position (FIG. 9) in which the pressure channel 236 is open, and a closed position (FIGS. 8 and 10) in which the pressure channel 236 is blocked. In the open position the sealing member 202a is spaced apart from the seat 204a thereby providing a fluid connection between the chamber 180a, tooling port 172a, and the pressure header 190. In the closed position the sealing member 202a contacts the seat 204a and fluidly isolates the chamber 184a from the pressure header 190.

In the illustrated example, an upper portion 206a of the vacuum closure member 192a and an upper portion 208a of the pressure closure member 200a is disposed within the chamber 184a, a lower portion 210a of the vacuum closure member 192 is disposed within the vacuum header 188, and a lower portion 212a of the pressure closure member 200a is disposed within the pressure header 190. Providing at least a portion of the closure members 192a and 200a within the chamber 184a and their respective headers 198, 200 may help reduce the overall size of the housing 164.

Referring to FIG. 6, vacuum closure member 192a-c is translatable along a respective axis 214a-c. In the illustrated example, the axes 214a-c are generally parallel to each other, and are spaced apart from each other along the length of the housing 164 by a distance 216. Alternatively, the housing 164 may be configured so that the axes 214a-c need not be parallel to each other.

Similarly, referring to FIG. 7, each pressure closure member 200a-c is translatable along a respective axis 218a-c (see also FIG. 9). In the illustrated example, the axes 218a-c of the pressure closure members 200a-c are generally parallel to each other and are spaced apart from each other along the length of the housing 160 by a distance 220. Optionally, the distance 220 can be the same as distance 216. Alternatively, the distance between the axes 214a-c may be different than the distance between the axes 218a-c. In the illustrated example, axes 218a-c are parallel to and spaced apart from axes 216a-c.

Referring to FIG. 8, in the illustrated example, the vacuum closure member 192a is configured to translate axially along axis 214a between its open and closed positions. The axial spacing 222a between the seal member 194a and the seat 196a when the vacuum member 192a is in its open position can be between about 3 mm and about 40 mm, or more. The size of the spacing 222a can be selected based on the size of chamber 184a, the number of receivers 154a, the diameter 180 of the vacuum port 166, and/or the diameter 178a of the tooling port 172a or other factors and can be chosen to provide a passage of sufficient size to allow for a desired amount of fluid flow from the tooling port 172a to the vacuum header 188. Referring to FIG. 9, the axial spacing 224a may be selected based on analogous factors.

Alternatively, instead of being axially translatable, at least one of the vacuum and or pressure closure members may be another type of suitable closure member having a different type of movement, including, for example, a pivoting closure member or a rotatable closure member.

In the illustrated example, the vacuum closure member **192a** is the only closure member fluidly positioned between the vacuum port **166** and the tooling port **172a**, and the pressure closure member **200a** is the only closure member fluidly positioned between the pressure port **168** and the tooling port **172a**. This may help simplify the operation of the valve assembly **160**. This may also help reduce pressure losses as fluid flows through the valve assembly **160** because the fluid need not pass through multiple valves, closure members or other flow metering devices.

Preferably, at least one actuator is provided to move the vacuum closure member **192a** and the pressure closure member **200a** between their respective open and closed positions. In the illustrated example, a separate actuator is provided for each of the vacuum and pressure closure members. This may help facilitate independent control of each closure member **192a**, **200a**. The actuator may be any suitable type of actuator, including, for example, pneumatic actuators, hydraulic actuators, electric actuators, mechanical actuators and any combination thereof. Alternatively, a single actuator may be configured to independently actuate more than one closure member.

Referring to FIG. 4, an actuator **226** is drivingly connected to the vacuum closure member (see also FIG. 10). Optionally, each actuator **226** may be independently and remotely controllable, for example via a valve assembly controller **228** to provide remote control of the vacuum closure member **192a**. The valve assembly controller **228** may be integrated within the control system for the injection molding machine **100**, or may be provided as a separate unit.

In the illustrated example, each actuator **226** includes a solenoid **230** that can be triggered by an electric control signal to control a pressurized air flow, supplied via pilot pressure port **238**, whereby the vacuum closure members **192a-c** can be selectably driven toward, or held in, their closed position (FIGS. 9 and 10), and the pressure closure members **200a-c** can be driven toward, or held in, their open positions (FIG. 9).

Optionally, a biasing member can be provided to bias the vacuum closure member toward its open and/or closed position. In the illustrated example, a biasing spring **230a** is provided within the housing **164** and is positioned to bias the vacuum closure member **192a** toward its open position (FIG. 8). To move the vacuum closure member **192a** to its closed position, the actuator **226** exerts a downward force (as illustrated in FIG. 9) to overcome the biasing force exerted by the spring **230a**. In the absence of an actuating force (for example during a power failure or other machine fault condition) the vacuum closure member **192a** will default to its open position. This may help ensure that vacuum remains applied to the transfer tubes **154a** during a fault condition. This may help retain molded articles within the transfer tubes **154a** during a fault. Alternatively, the vacuum closure member **192a** may be configured so that it is biased toward its closed position, and the actuator is configured to drive the vacuum closure member toward its open position.

A biasing member may be provided to bias the pressure closure member **200a** toward its open and/or closed position.

In the illustrated example, a biasing spring **232a** is provided within the housing **164** and is positioned to bias the pressure closure member **200a** toward its closed position (FIG. 8). To move the pressure closure member **200a** to its closed position, its actuator **226** exerts a downward force (as illustrated in FIG. 9) to overcome the biasing force exerted by the spring **232a**. In the absence of an actuating force (for example during a power failure or other machine fault condition) the pressure closure member **200a** will default to its closed position. This may help ensure that the pressurized fluid flow to the transfer tubes **154a** is turned off during a fault condition.

In the illustrated example, the vacuum closure member **192a** is moveable independently from the pressure closure member **200a**. The vacuum closure member **192a** is also moveable independently from the other vacuum closure members **192b** and **192c**, and the other pressure closure members **200b** and **200c**. This independent movement of the vacuum closure member **192a** and pressure closure member **200a** may help reduce or eliminate the likelihood of cross-flow between the vacuum header **188** and pressure header **190** when switching between vacuum suction and pressurized fluid flows.

For example, when switching the tooling port **172a** from applying vacuum to its set of pressure tubes **154a** to the application of pressurized fluid to its set of pressure tubes **154a**, such independent movement allows vacuum closure member **192a** to be closed before the pressure closure member **200a** is opened. This may prevent fluid communication between the pressure header **190** and the vacuum header **188**. Such cross-flow may have allowed at least some of the supplied pressurized fluid to be sucked out via the vacuum header **188** without reaching the tooling port **172a** or tubes **154a**. Similarly, the pressure closure member **200a** can be closed prior to opening the vacuum closure member **192a** when switching from applying pressurized fluid to applying vacuum to the first set of pressure tubes **154a**.

This independent movement of each closure member **192a** and **200a** may also enable the valve assembly **160** to be configured to provide a plurality of operating configurations, to provide different combinations of conditions at its tooling ports **172a-c**. Optionally, the valve assembly **160** can be configured so that one tooling port is under vacuum while another tooling port is receiving pressurized fluid or is off (i.e. both the vacuum closure member and pressure closure member are closed). For example, the valve assembly **160** can be configured so that the vacuum closure member **192a** is open while the vacuum closure members **192b** and **192c** and pressure closure members **200a-c** are all closed, thereby providing vacuum to tooling port **172a** while, tooling ports **172b** and **172c** are off.

The valve assembly **160** can also be configured so that the pressure closure member **200a** is open, providing pressurized fluid to tooling port **172a**, while pressure closure members **200b** and **200c** and vacuum closure members **192a-c** are closed, whereby tooling ports **172b** and **172c** are off.

In the illustrated example, the valve assembly **160** having three valve sub-assemblies **170a-c** may be configured in a plurality of operating configurations, including, for example those illustrated below:

Valve Sub-Assembly 170a			Valve Sub-Assembly 170b			Valve Sub-Assembly 170c		
Vacuum Closure Member 192a	Pressure Closure Member 200a	Tooling Port 172a	Vacuum Closure Member 192b	Pressure Closure Member 200b	Tooling Port 172b	Vacuum Closure Member 192c	Pressure Closure Member 200c	Tooling Port 172c
Closed	Closed	Off	Closed	Closed	Off	Closed	Closed	Off
Closed	Closed	Off	Closed	Closed	Off	Open	Closed	Vacuum
Closed	Closed	Off	Closed	Closed	Off	Closed	Open	Pressure
Closed	Closed	Off	Open	Closed	Vacuum	Closed	Closed	Off
Closed	Closed	Off	Open	Closed	Vacuum	Open	Closed	Vacuum
Closed	Closed	Off	Open	Closed	Vacuum	Closed	Open	Pressure
Closed	Closed	Off	Closed	Open	Pressure	Closed	Closed	Off
Closed	Closed	Off	Closed	Open	Pressure	Open	Closed	Vacuum
Closed	Closed	Off	Closed	Open	Pressure	Closed	Open	Pressure
Open	Closed	Vacuum	Closed	Closed	Off	Closed	Closed	Off
Open	Closed	Vacuum	Closed	Closed	Off	Open	Closed	Vacuum
Open	Closed	Vacuum	Closed	Closed	Off	Closed	Open	Pressure
Open	Closed	Vacuum	Open	Closed	Vacuum	Closed	Closed	Off
Open	Closed	Vacuum	Open	Closed	Vacuum	Open	Closed	Vacuum
Open	Closed	Vacuum	Open	Closed	Vacuum	Closed	Open	Pressure
Open	Closed	Vacuum	Closed	Open	Pressure	Closed	Closed	Off
Open	Closed	Vacuum	Closed	Open	Pressure	Open	Closed	Vacuum
Open	Closed	Vacuum	Closed	Open	Pressure	Closed	Open	Pressure
Closed	Open	Pressure	Closed	Closed	Off	Closed	Closed	Off
Closed	Open	Pressure	Closed	Closed	Off	Open	Closed	Vacuum
Closed	Open	Pressure	Closed	Closed	Off	Closed	Open	Pressure
Closed	Open	Pressure	Open	Closed	Vacuum	Closed	Closed	Off
Closed	Open	Pressure	Open	Closed	Vacuum	Open	Closed	Vacuum
Closed	Open	Pressure	Open	Closed	Vacuum	Closed	Open	Pressure
Closed	Open	Pressure	Closed	Open	Pressure	Closed	Closed	Off
Closed	Open	Pressure	Closed	Open	Pressure	Open	Closed	Vacuum
Closed	Open	Pressure	Closed	Open	Pressure	Closed	Open	Pressure

Varying the number of valve sub-assemblies **170** in the valve assembly **160** may vary the number and type of configurations that can be provided by a given valve assembly.

In the illustrated example, the vacuum closure member **192a** and pressure closure member **200a** are separate members that are moveable independently of each other. Alternatively, the vacuum closure member **192a** and pressure closure member **200a** may be connected to each other, formed from a single member or otherwise provided in any suitable manner while still allowing both closure members **192a** and **200a** to be independently, selectably opened and closed relative to each other and to be simultaneously closed when desired.

While in the example illustrated the valve assembly **160** has three valve sub-assemblies **170**, optionally, the valve assembly **160** may have fewer than three or more than three valve sub-assemblies **170**. The number of valve sub-assemblies may be selected based at least partially on the number of sets of receivers **154** that are to be connected to the valve assembly. Providing at least one valve sub-assembly **170** per set of receivers **154** may help facilitate independent control of the supply of vacuum suction and pressurized air to each set of receivers **154**.

Optionally, in addition to be operable to provide independently selectable vacuum suction or pressurized air to each tooling port **172a**, **172b** and **172c**, the valve assembly **160** may also be configured to provide more than one level of vacuum suction. Such a configuration may be useful in a variety of applications, including for example, if a relatively high level of vacuum suction is desired to transfer parts into receiving tubes **154**, and only a relatively lower level of vacuum suction is required to hold the parts in the receiving tubes **154**.

Optionally, to help provide multiple levels of vacuum suction, the valve assembly **160** may include a vacuum selector valve that is provided between the vacuum source **156** and the

vacuum port **166**. The vacuum selector valve may be incorporated within the housing **164**, or provided as a separate module that is external the housing **164**.

Referring to FIG. **11**, one example of a vacuum selector valve **240** is positioned outside and connected to the housing **164**. The selector valve includes a housing **242** having an outer face **244** (facing away from the housing **164**) and a mounting face **246** (FIG. **13**) facing, and abutting the end face of the housing **164**).

In the illustrated example, the outer face **244** includes a high vacuum port **248**, a pressurized air port **250**, a vacuum brake port **252**, a low vacuum port **254** and an actuator pilot pressure port **256** (FIG. **12**).

Referring to FIG. **12**, the high vacuum port **248** is connectable to a suitable vacuum source and has a diameter **258**. The diameter **258** can be selected to accommodate a desired volume of air flow under high vacuum operation, and can be the generally the same as, or different than the diameter **180** of vacuum port **166**.

The pressurized air port **250** is connectable to a supply of pressurized air, such as pressurized air source **158**. In the illustrated example, when the vacuum selector valve **240** is mounted on the housing **164**, the pressurized air port **252** is registered with pressure port **168** and the pressurized air port **250** is functions as an unswitched, flow through channel facilitating fluid flow between port **168** and source **158**. Alternatively, the vacuum selector valve **240** may include any suitable type of closure member to selectively block the pressurized air port **252**.

The vacuum brake port **252** is configured to provide an alternate source of air that can be drawn into the vacuum system, in alternative to or in addition to air that is drawn in through one of the tooling ports **172a-c**. The vacuum brake port **252** may be connected to any suitable supply of air, or, as in the illustrated example, may simply be in communication

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with the surrounding atmosphere. Optionally, a filter member (not shown) may be used to screen air entering the vacuum brake port 252.

The low vacuum inlet port 254 can be connected to any suitable vacuum source, including for example, source 156. In the illustrated example, the low vacuum port 254 has a diameter 260 that is smaller than the diameter 258 of high vacuum port 248. Having a smaller diameter may limit the volume of fluid that can flow through the low vacuum port 254 relative to the high vacuum port 248 when coupled to a similar upstream vacuum source.

The pilot pressure port 256 extends through the housing 242. When the housing 242 is mounted on the housing 164, the pilot pressure port 256 is registered with pilot pressure port 238 and provides fluid communication between port 238 and its fluid source. Pilot pressure port 256 also supplies fluid to actuators 262, which may be any suitable actuator, but in the example illustrated are generally similar to actuators 226.

Referring to FIG. 13, the mounting face 246 of the housing 242 includes pilot pressure port 256 and pressurized air port 250 (as explained above) and a vacuum coupling port 264. The vacuum coupling port 264 is positioned so that when the housing 242 is mounted on housing 164, the vacuum coupling port 264 is registered with and coupled to vacuum port 166. In this configuration, the vacuum coupling port 264 provides fluid connection between the high vacuum port 248, low vacuum port 254 and the vacuum port 166. The vacuum coupling port 264 can be sized and shaped to generally correspond with the size and shape of vacuum port 166, and may have a diameter 266 that is generally equal to diameter 180.

Optionally, all of the openings on the mounting face 246 may be provided with gaskets, o-rings or other suitable sealing members to help provide a fluid tight seal between the ports on the mounting face 246 and the corresponding ports on the housing 164.

Referring to FIG. 15, in the illustrated example, the interior of the housing 242 defines a fluid flow channel, including a chamber 268 which fluidly connects high vacuum port 248, low vacuum port 254, vacuum brake port 252 and vacuum coupling port 264. A low vacuum closure member 270 and a high vacuum closure member 272 are positioned within the chamber 268, and can be selectably driven by respective ones of the actuators 262.

Referring to FIG. 15, in the illustrated example the low vacuum closure member 270 includes a sealing member 274 (such as a gasket, o-ring or other suitable member) that can contact and seal against a corresponding seat 276 in the chamber 268. The low vacuum closure 270 is moveable between an open position (FIG. 17) in which the sealing member 274 is spaced apart from seat 276 and the vacuum brake port 252 is fluid communication with the chamber 268, and a closed position (FIGS. 15 and 16) in which the sealing member 274 is sealed against seat 276 and fluid communication with the vacuum brake port 252 is blocked. In the illustrated example, the low vacuum closure member 270 is biased toward its closed position by a biasing member, for example spring 288.

Similarly, referring to FIG. 16, the high vacuum closure member 272 includes a sealing member 278 that can contact and seal against a corresponding seat 280 in the chamber 286. The high vacuum closure member 272 is moveable between an open position (FIG. 16) the sealing member 278 is spaced apart from seat 280 and the high vacuum port 248 is in fluid communication with the chamber 268, and a closed position (FIGS. 15 and 17) in which the sealing member 278 is sealed against seat 280 and the high vacuum port 248 is fluidly isolated from the chamber 268. In the illustrated example, the

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high vacuum closure member 272 is biased toward its closed position by a biasing member, for example spring 290.

Referring to FIG. 15, to provide relatively low vacuum suction to vacuum port 166, the vacuum selector valve 240 can be configured to that both the low vacuum closure member 270 and the high vacuum closure member 272 are closed. In this configuration, the low vacuum port 254 is in fluid communication with the vacuum coupling port 264 and the vacuum port 166 connected thereto.

Referring to FIG. 16, to provide relatively high vacuum suction to vacuum port 166, the vacuum selector valve 240 can be configured to that the low vacuum closure member 270 is closed and the high vacuum closure member 272 is open. In this configuration, both the low vacuum port 254 and the high vacuum port 248 are in fluid communication with the vacuum coupling port 264 and the vacuum port 166 connected thereto, thereby providing relatively high levels of vacuum suction.

Referring to FIG. 17, to provide no vacuum suction (or virtually no vacuum suction) to vacuum port 166 (which may be useful, for example, when all of the vacuum closure members 192 are closed), the vacuum selector valve 240 can be configured to that the low vacuum closure member 270 is open and the high vacuum closure member 272 is closed. In this configuration, the high vacuum port 248 is fluidly isolated from the chamber 268, and the vacuum brake port 252 is in fluid communication with the low vacuum port 254, which permits air to drawn into the vacuum system from the surrounding atmosphere.

While illustrated in combination with the take-out plate 148, the valve assembly 160, or a variation thereof, may also be used in combination with the end station 162, cooling shell 142 or any other suitable part handling apparatus having a plurality of receivers. Optionally, the injection molding machine 100 may include two or more valve assemblies 160, associated with different part handling apparatuses.

What has been described above has been intended to be illustrative of the invention and non-limiting and it will be understood by persons skilled in the art that other variants and modifications may be made without departing from the scope of the invention as defined in the claims appended hereto.

The invention claimed is:

1. A valve assembly for use with a part handling assembly of an injection molding machine, the part handling assembly having at least two sets of receivers, the valve assembly comprising:

- a) a housing having a first tooling port for fluid communication with a first set of receivers on the part handling apparatus and a second tooling port for fluid communication with a second set of receivers on the part handling apparatus;
- b) a first vacuum channel extending through the housing and providing fluid communication between the first tooling port and a vacuum source;
- c) a first vacuum closure member moveable between an open position, in which the first vacuum channel is open, and a closed position, in which the first vacuum channel is blocked, to selectably permit fluid communication between the first tooling port and the vacuum source;
- d) a first pressure channel extending through the housing and providing fluid communication between the first tooling port and a pressurized fluid source;
- e) a first pressure closure member moveable between an open position, in which the first pressure channel is open, and a closed position, in which the first pressure channel is blocked, to selectably permit fluid communication between the first tooling port and the pressurized

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fluid source, the first pressure closure member moveable independently from the first vacuum closure member;

f) a second vacuum channel extending through the housing and providing fluid communication between the second tooling port and the vacuum source;

g) a second vacuum closure member moveable between an open position, in which the second vacuum channel is open, and a closed position, in which the second vacuum channel is blocked, to selectably permit fluid communication between the second tooling port and the vacuum source;

h) a second pressure channel extending through the housing and providing fluid communication between the second tooling port and the pressurized fluid source;

i) a second pressure closure member moveable between an open position, in which the first pressure channel is open, and a closed position, in which the second pressure channel is blocked, to selectably permit fluid communication between the second tooling port and the pressurized fluid source, the second pressure closure member moveable independently from the second vacuum closure member.

2. The valve assembly of claim 1, wherein the first vacuum closure member is moveable independently from the second vacuum closure member.

3. The valve assembly of claim 1, wherein the housing further comprises a vacuum port, the first vacuum channel extends between the vacuum port and the first tooling port, and the second vacuum channel extends between the vacuum port and the second tooling port.

4. The valve assembly of claim 3, wherein the first vacuum closure member is the only closure member operable to block the first vacuum channel between the vacuum port and the first tooling port.

5. The valve assembly of claim 3, wherein the second vacuum closure member is the only closure member fluidly connected between the vacuum port and the second tooling port.

6. The valve assembly of claim 3, further comprising a vacuum header disposed within the housing and extending from, and in fluid communication with, the vacuum port, the vacuum header comprising a portion of both the first and second vacuum channels.

7. The valve assembly of claim 3, wherein the housing comprises a pressure port, the first pressure channel extends between the pressure port and the first tooling port, and the second pressure channel extends between the pressure port and the second tooling port.

8. The valve assembly of claim 7, further comprising a pressure header disposed within the housing and extending from, and in fluid communication with, the pressure port, the pressure header comprising a portion of both the first and second pressure channels.

9. The valve assembly of claim 8, further comprising a first internal chamber disposed within the housing and forming part of the first vacuum channel, the first internal chamber in fluid communication with first tooling port and comprising a first vacuum opening providing fluid communication between the vacuum header and the first internal chamber, wherein when the first vacuum closure member is in the closed position the first vacuum closure member seals the first vacuum opening.

10. The valve assembly of claim 9, wherein the first internal chamber further comprises a first pressure opening providing fluid communication between the pressure header and the first internal chamber, wherein when the first pressure closure

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member is in the closed position the first pressure closure member seals the first pressure opening.

11. The valve assembly of claim 9, further comprising a second internal chamber spaced apart from the first internal chamber and disposed within the housing, the second internal chamber forming part of the second vacuum channel, being in fluid communication with the second tooling port, and comprising a second vacuum opening providing fluid communication between the vacuum header and the second internal chamber, wherein when the second vacuum closure member is in the closed position the second vacuum closure member seals the second vacuum opening.

12. The valve assembly of claim 11, wherein the second internal chamber further comprises a second pressure opening providing fluid communication between the pressure header and the second internal chamber, and when the second pressure closure member is in the closed position the second pressure closure member seals the second pressure opening.

13. The valve assembly of claim 12, wherein the first vacuum opening comprises a first vacuum opening fluid flow area and the first pressure opening comprises a first pressure opening fluid flow area, and the first vacuum opening fluid flow area is at least 200% larger than the first pressure opening fluid flow area.

14. The valve assembly of claim 1, further comprising a first vacuum actuator connected to the first vacuum closure member and a first pressure actuator connected to the first pressure closure member, wherein the first vacuum actuator is independently actuatable from the first pressure actuator for independent movement of the first vacuum closure member and the first pressure closure member between respective open and closed positions.

15. The valve assembly of claim 1, wherein the first vacuum closure member is translatable along a first vacuum axis between the open and closed positions.

16. The valve assembly of claim 15, wherein the first pressure closure member is translatable along a first pressure axis between the open and closed positions.

17. The valve assembly of claim 16, wherein the first vacuum axis is generally parallel to and spaced apart from the first pressure axis.

18. The valve assembly of claim 17, wherein the second vacuum closure member is translatable along a second vacuum axis between its open and closed positions, and wherein the second vacuum axis is generally parallel to and spaced apart from the first vacuum axis.

19. The valve assembly of claim 1, wherein the housing is of unitary, integrally formed one-piece construction.

20. The valve assembly of claim 1, wherein the first vacuum channel is sized to accommodate a volumetric flow rate of between about 100 liters per minute and about 750 liters per minute.

21. The valve assembly of claim 1, further comprising a vacuum selector valve disposed in fluid communication between the vacuum source and the first tooling port.

22. A part handling assembly for use with an injection molding machine, the part handling assembly comprising:

a) a first set of receivers for receiving a first set of molded articles;

b) at least a second set of receivers adjacent the first set of receivers for receiving a second set of molded articles;

c) a valve assembly for controlling airflow to the first and at least second sets of receivers, the valve assembly including:

i) a housing having a first tooling port for fluid communication with a first set of receivers on the part han-

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- dling apparatus and a second tooling port for fluid communication with a second set of receivers on the part handling apparatus;
- ii) a first vacuum channel extending through the housing and providing fluid communication between the first tooling port and a vacuum source; 5
- iii) a first vacuum closure member moveable between an open position, in which the first vacuum channel is open, and a closed position, in which the first vacuum channel is blocked, to selectably permit fluid communication between the first tooling port and the vacuum source; 10
- iv) a first pressure channel extending through the housing and providing fluid communication between the first tooling port and a pressurized fluid source; 15
- v) a first pressure closure member moveable between an open position, in which the first pressure channel is open, and a closed position, in which the first pressure channel is blocked, to selectably permit fluid communication between the first tooling port and the pressurized fluid source, the first pressure closure member moveable independently from the first vacuum closure member; 20

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- vi) a second vacuum channel extending through the housing and providing fluid communication between the second tooling port and the vacuum source;
- vii) a second vacuum closure member moveable between an open position, in which the second vacuum channel is open, and a closed position, in which the second vacuum channel is blocked, to selectably permit fluid communication between the second tooling port and the vacuum source;
- viii) a second pressure channel extending through the housing and providing fluid communication between the second tooling port and the pressurized fluid source; and
- ix) a second pressure closure member moveable between an open position, in which the first pressure channel is open, and a closed position, in which the second pressure channel is blocked, to selectably permit fluid communication between the second tooling port and the pressurized fluid source, the second pressure closure member moveable independently from the second vacuum closure member.

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